ROYAL
SOCIETY
OF ARTS

JOURNAL

67
1918-19

JOURNAL

OF THE

ROYAL

SOCIETY OF ARTS

VOLUME LXVII.

FROM NOVEMBER 22, 1918, TO NOVEMBER 14, 1919.

LONDON:

PUBLISHED FOR THE SOCIETY BY G. BELL & SONS, LTD.,
YORK HOUSE, PORTUGAL STREET, LINCOLN'S INN FIELDS, W.C. 2

1919

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
DUKE STREET, STAMFORD STREET, S.E. 1, AND GREAT WINDMILL STREET, W. 1.

No. 3444. NOVEMBER 22, 1918. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C 2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2)

Journal of the Royal Society of Arts.

No. 3,444. VOL. LXVII.

FRIDAY, NOVEMBER 22, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

ONE-HUNDRED-AND-SIXTY-FIFTH SESSION, 1918-1919.

SESSIONAL ARRANGEMENTS.

The Opening Meeting of the One Hundred and Sixty-Fifth Session was held on Wednesday, November 20th, when an address was delivered by ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, on "Science and the Future." (See pp. 7-19, below.)

PAPERS TO BE READ BEFORE CHRISTMAS.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

NOVEMBER 27.—LORD D'ABERNON, G.C.M.G., Chairman, Central Control Board (Liquor Traffic), "Rival Theories of the Causes of Drunkenness." SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., F.R.S., Past-President of the Royal College of Physicians, will preside.

DECEMBER 4.—BENJAMIN SEEBOHM ROWNTREE, "Housing after the War." LORD HENRY CAVENDISH BENTINCK, M.P., will preside.

" 11.—MAJOR-GENERAL SIR FREDERICK SMITH, K.C.M.G., C.B., F.R.C.V.S., "The Work of the British Army Veterinary Corps at the Fronts." The DUKE OF PORTLAND, K.G., G.C.V.O., will preside.

COLONIAL SECTION.

Thursday afternoon, at 4.30 p.m.:—

NOVEMBER 21.—SIR EVERARD IM THURN, K.C.M.G., C.B., LL.D., "The Present State of the Pacific Islands." SIR CHARLES LUCAS, K.C.B., K.C.M.G., will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.:—

NOVEMBER 28.—BHUPENDRANATH BASU, Member of the Council of India, "Some Aspects of Hindu Life." The Most Honourable the MARQUIS OF CREWE, K.G., will preside.

PAPERS TO BE READ AFTER CHRISTMAS.

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S. (Subject to be announced later.)

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

FREDERICK WILLIAM KEEBLE, C.B.E., M.A., Sc.D., F.R.S. (Director of Horticulture, Food Production Department), "Food Production by Intensive Cultivation."

B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

A. F. KENDRICK, Department of Textiles, Victoria and Albert Museum, "English Carpets."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

LIEUTENANT-COLONEL H. G. LYONS, D.Sc., F.R.S., "Meteorology during and after the War."

W. L. HICHENS (Messrs. Cammel Laird & Co.), "The Wage Problem in Industry."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

J. F. CROWLEY, D.Sc., "The Use of Electricity in Agriculture in Germany."

SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

PROFESSOR JOHN CUNNINGHAM McLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

SANDFORD J. KILBY, "Indian Salt Manufacture."

H. KELWAY-BAMBER, M.V.O., "Coal and Mineral Traffic on the Indian Railways."

PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Exhaustion in India and its Influence on the Value of Crops."

THE RIGHT HON. LORD MONTAGU OF BEAULIEU, V.D. (Subject to be announced later.)

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

January 16, February 13, March 13, April 3, May 15.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

February 4, March 4, May 6.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced) :—

JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." Three lectures. At 5 p.m.

LECTURE I.—DECEMBER 2.—Principles of chemical equilibrium—Their application in technical gas reactions—Sulphuric acid contact process—Influence of pressure and temperature on yield—Synthetic ammonia—The water-gas equilibrium.

LECTURE II.—DECEMBER 9.—The *rôle* of the catalyst from the standpoint of physical chemistry—Catalysts in solution and in solid form—Catalysis in industry—Hardening of fats—Surface combustion—Oxidation of ammonia—Enzyme action—Acetaldehyde from acetylene.

LECTURE III.—DECEMBER 16.—Physical chemistry of the absorption of gases and dissolved substances—Solubility of gases in liquids as affected by pressure—Storage of acetylene—Charcoal as an absorbent of gases—Production of high vacua—Absorption of colouring matters from solution—Fuller's earth and charcoal—The dyeing process—Adsorption in soils.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m. :—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "Liquid Drops and Globules." Two Lectures.

January 1, 8.

PROCEEDINGS OF THE SOCIETY.

THE SOCIETY was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom: and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country." In 1908 the Society was granted the privilege of adding "Royal" to its title.

FELLOWSHIP.—At the Annual General Meeting held on June 24th, 1914, a By-Law was made, authorising all Members of the Society to use the designation of Fellow.

ORDINARY MEETINGS.—Meetings are held every Wednesday during the Session, at which papers on subjects relating to inventions, improvements, discoveries, and other matters connected with Arts, Manufactures, and Commerce are read and discussed.

Indian Section.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

Colonial Section.—This Section was formed in 1874 under the title of the African Section. It was enlarged in 1879, to include the consideration of subjects connected with the Colonies and Dependencies. Four or more Meetings are held during the Session.

Cantor Lectures.—These Lectures originated in 1863, with a bequest by Dr. Cantor. The Lectures deal with the latest applications of Science and Art to practical purposes, and are, as far as possible, experimentally illustrated.

Fothergill Lectures.—Courses of Lectures, similar to the Cantor Lectures, are given from time to time under this bequest.

Howard Lectures.—The bequest of Mr. Thomas Howard (1872) is now devoted to occasional courses of Lectures on motive power and its applications.

Shaw Lectures.—Under the Shaw bequest Lectures on Industrial Hygiene are given from time to time.

Aldred Lecture.—The bequest of the late Dr. Aldred has been devoted to the establishment of an Annual Lecture.

Cobb Lectures.—Funds have been provided for occasional Lectures in memory of the late Mr. Francis Cobb.

Juvenile Lectures.—A Short Course of Lectures, suited for a Juvenile audience, is delivered to the children of Fellows during the Christmas holidays.

Admission to Meetings.—Members have the right of attending the Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Fellow can admit two friends to the Ordinary and Sectional Meetings, and to the Cantor and other Lectures. Books of tickets for the purpose are supplied, but admission can also be obtained on the personal introduction of a Fellow. For the Juvenile Lectures special tickets are issued.

Journal of the Royal Society of Arts.—The *Journal*, which is sent free to Fellows, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

Examinations.—Examinations, founded in 1854, are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person. The subjects include the principal elements of Commercial Education and Music. Full particulars can be obtained on application to the Secretary.

Library and Reading-room.—The Library and Reading-room are open to Fellows, who are also entitled to borrow books.

A History of the Society, written by Sir Henry Trueman Wood, Secretary of the Society from 1879 to 1917, has lately been published (John Murray, pp. 558, 15*s.* net), and can be obtained from any bookseller. It gives a history of the Society's work from 1754 to 1880.

Conversazioni are held, to which Fellows are invited, each Fellow receiving a card for himself and a lady.

Election of Fellows.—Candidates are proposed by Three Fellows, one of whom, at least, must sign on personal knowledge; or are nominated by the Council.

The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day preceding election; or a Life Subscription of Twenty Guineas may be paid. There is no Entrance Fee.

CALENDAR FOR THE SESSION.

The following is the Calendar for the Session 1918–1919. It is issued subject to any necessary alterations:—

NOVEMBER, 1918

1	F	
2	S	
3	S	
4	M	
5	Tu	
6	W	
7	Th	
8	F	
9	S	
10	S	
11	M	
12	Tu	
13	W	
14	Th	
15	F	
16	S	
17	S	
18	M	
19	Tu	[the Session
20	W	Opening Meeting of
21	Th	Colonial Section
22	F	
23	S	
24	S	
25	M	
26	Tu	
27	W	Ordinary Meeting
28	Th	Indian Section
29	F	
30	S	

DECEMBER, 1918

1	S	
2	M	Cantor Lecture I. 1
3	Tu	
4	W	Ordinary Meeting
5	Th	
6	F	
7	S	
8	S	
9	M	Cantor Lecture I. 2
10	Tu	
11	W	Ordinary Meeting
12	Th	
13	F	
14	S	
15	S	
16	M	Cantor Lecture I. 3
17	Tu	
18	W	
19	Th	
20	F	
21	S	
22	S	
23	M	
24	Tu	
25	W	CHRISTMAS DAY
26	Th	*Bank Holiday*
27	F	
28	S	
29	S	
30	M	
31	Tu	

JANUARY, 1919

1	W	Juvenile Lecture I.
2	Th	
3	F	
4	S	
5	S	
6	M	
7	Tu	
8	W	Juvenile Lecture II.
9	Th	
10	F	
11	S	
12	S	
13	M	
14	Tu	
15	W	Ordinary Meeting
16	Th	Indian Section
17	F	
18	S	
19	S	
20	M	
21	Tu	
22	W	Ordinary Meeting
23	Th	
24	F	
25	S	
26	S	
27	M	
28	Tu	
29	W	Ordinary Meeting
30	Th	
31	F	

FEBRUARY, 1919

1	S	
2	S	
3	M	
4	Tu	Colonial Section
5	W	Ordinary Meeting
6	Th	
7	F	
8	S	
9	S	
10	M	Cantor Lecture II. 1
11	Tu	
12	W	Ordinary Meeting
13	Th	Indian Section
14	F	
15	S	
16	S	
17	M	Cantor Lecture II. 2
18	Tu	
19	W	Ordinary Meeting
20	Th	
21	F	
22	S	
23	S	
24	M	Cantor Lecture II. 3
25	Tu	
26	W	Ordinary Meeting
27	Th	
28	F	

MARCH, 1919

1	S	
2	S	
3	M	
4	Tu	Colonial Section
5	W	Ordinary Meeting
6	Th	
7	F	
8	S	
9	S	
10	M	Cantor Lecture III. 1
11	Tu	
12	W	Ordinary Meeting
13	Th	Indian Section
14	F	
15	S	
16	S	
17	M	Cantor Lecture III. 2
18	Tu	
19	W	Ordinary Meeting
20	Th	
21	F	
22	S	
23	S	
24	M	Cantor Lecture III. 3
25	Tu	
26	W	Ordinary Meeting
27	Th	
28	F	
29	S	
30	S	
31	M	

APRIL, 1919

1	Tu	
2	W	Ordinary Meeting
3	Th	Indian Section
4	F	
5	S	
6	S	
7	M	
8	Tu	
9	W	Ordinary Meeting
10	Th	
11	F	
12	S	
13	S	
14	M	
15	Tu	
16	W	
17	Th	
18	F	GOOD FRIDAY
19	S	
20	S	EASTER SUNDAY
21	M	*Bank Holiday*
22	Tu	
23	W	
24	Th	
25	F	
26	S	
27	S	
28	M	
29	Tu	
30	W	Ordinary Meeting

MAY, 1919

1	Th	
2	F	
3	S	
4	S	
5	M	Cantor Lecture IV. 1
6	Tu	Colonial Section
7	W	Ordinary Meeting
8	Th	
9	F	
10	S	
11	S	
12	M	Cantor Lecture IV. 2
13	Tu	
14	W	Ordinary Meeting
15	Th	Indian Section
16	F	
17	S	
18	S	
19	M	Cantor Lecture IV. 3
20	Tu	
21	W	Ordinary Meeting
22	Th	
23	F	
24	S	
25	S	
26	M	
27	Tu	
28	W	Ordinary Meeting
29	Th	
30	F	
31	S	

JUNE, 1919

1	S	
2	M	
3	Tu	
4	W	
5	Th	
6	F	
7	S	
8	S	WHIT SUNDAY
9	M	*Bank Holiday*
10	Tu	
11	W	
12	Th	
13	F	
14	S	
15	S	
16	M	
17	Tu	
18	W	
19	Th	
20	F	
21	S	
22	S	
23	M	
24	Tu	
25	W	Annual General
26	Th	Meeting
27	F	
28	S	
29	S	
30	M	

The Cantor Lectures, the Ordinary Meetings, and the Meetings of the Indian Section and the Colonial Section will be held (unless otherwise announced) at Half-past Four o'clock.

The Annual General Meeting will be held at Four o'clock.

The Juvenile Lectures will be given at Three o'clock.

NOTICE.

CANTOR LECTURES.

The Cantor Lectures on "Military Explosives of To-day," by J. Young, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, have been reprinted from the *Journal*, and the pamphlet (price 1*s.* 6*d.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2).

A full list of the Lectures which have been published separately, and are still on sale, can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

FIRST ORDINARY MEETING.

Wednesday, November 20th, 1918; ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Adam, Felix, Boulogne-sur-Mer.
Adam, James Millen, Helensburgh, N.B.
Appleton, Aaron, J.P., Litherland, Lancs.
Appleyard, George Henry, Rotherham.
Arnold, John Thomas, Manchester.
Baker, Charles Alfred, London.
Barlow, C. T., Birmingham.
Barry, John, J.P., Kirkcaldy.
Bayley, Captain Sir Henry Dennis, K.B.E., J.P., D.L., Nottingham.
Bayliss, Horace William, Wellington, Salop.
Beveridge, William K., Warwick.
Bickerton, Henry Nield, Chelford, Cheshire.
Bougatsos, Christos C., Cairo, Egypt.
Boulden, H. J., Ferguson, Mo., U.S.A.
Bowman, William Powell, Leeds.
Brocklebank, Ralph, J.P., D.L., Tarporley.
Brown, Thomas, J.P., Leicester.
Burnside, Thomas D. M., London.
Campion, John Montriou, M.Inst.C.E., London.
Castle, George, Brighton.
Chalmers, John Reid, Glasgow.
Chapman, Edwin John, London.
Christie, Colville, Queensland.
Clarkson, Thomas, M.Inst.C.E., M.I.Mech.E., A.R.S.M., Wh.Sc., Galleywood, Essex.
Clibborn, Lieut.-Col. John, C.I.E., F.R.M.S., London.
Coomer, John, Rochdale.
Cooper, Jasper E., M.I.N.A., M.I.Mech.E., M.I.A.E., Birmingham.
Copsey, William A., M.I.A.E., A.M.I.Mech.E., Narborough, Leicestershire.
Courtin, Leopold, London.
Cowan, Sir John, D.L., J.P., Edinburgh.
Craig, Robert, M.S.C.I., Bromborough, Cheshire.
Crombie, Aymer Ernest, London.
de Buriatte, Henry John Allan Isaac, F.C.I.S., London.
de Sampayo, F. Q., London.
Dessen, H. F., London.
Dew, James Walter Henry, London.
Dewar, Peter M., London.
Dhawan, Lala Ikhtiari Lal, B.A., Patiala, India.
Donisthorpe, Frederick Russell, Leicester.
Down, John Richard, Swansea.
Duffy, Joseph, Woldingham, Surrey.
Dugard, George H., Sutton Coldfield.
Eakin, William C. W., F.R.G.S., Nigeria.
Elias, E. A., Singapore.
Elliott, E. J., Belfast.
Elliott-Garwood, Ivor William, Cardiff.
Ellis, George Ernest, Loughborough.
Ellis, Percival W., Pyrford, Surrey.
Euesden, Philip Henry, London.
Evans, Arthur F., M.I.A.E., London.
Evans, Malcolm T., Bristol.
Fairlie, John Clowes, B.Sc., Falkirk.
Feeny, Victor Fallon, M.I.A.E., London.
Filshill, James, Glasgow.
Forman, James, Nottingham.
Foster, Albert William, Lincoln.
Foster, Thomas, Levenshulme.
Gibbs, John Edward, M.I.A.E., A.M.I.Mech.E., York.
Gilliespie, William W., Grangemouth.
Gray, George Davidson, Aberdeen.
Guillaume, Henri, Redditch.
Hardy, Thomas William, Nottingham.
Harrington, Frank, Calcutta.
Harris, H. Wightman, London.
Hayes, Alfred Edward, London.
Heelis, Frederick, F.R.G.S., Watford.
Hepworth, Herbert Morton, Headingley, Leeds.
Hereford, G. A., Penang, Straits Settlements.
Hodgkinson, Frederick, Blackburn.
Hooper, John, St. Dennis, Cornwall.
Hull, Edmund Charles Pendleton, J.P., Redhill.
Husband, John Irons, London.
Illingworth, Ralph, Shipley, Yorks.
Indian Trade Commissioner, London.
Inglefield, Mrs. Julia Katharine Margaret, Beaconsfield, Bucks.
Inglis, George Alexander, B.Sc., Glasgow.
Ireland, Adam Liddell, Belfast.
Johnson, Leo Fred Edmund, London.
Johnston, J. Clement, Cambridge.
Johnston, John, Lurgan, Ireland.
Kelway, James, Langport, Somerset.
Khan, Khan Bahadur Mansab Hasan, United Provinces, India.
Kikuchi, Mikitaro, London.
Kincaid, John G., Greenock.
Kirk, Captain James Robert, New Zealand.
Kirk, T. Croisdale, Cardiff.
Lacy, Francis Brandon, Northwood.
Laming, Henry, London.
Lang, G. J. Lockwood, Saltash.

Layton, Edwin J., London.
Lee, Edward Geoffrey, Bangkok, Siam.
Leeds University Library, The Librarian of, Leeds.
Leven, Charles, M.I.E.E., London.
Levinstein, Herbert, M.Sc., Ph.D., F.I.C., Manchester.
Liversedge, Alfred John, Assoc.M.Inst.C.E., London.
Lo Hin Shing, B.A., Hong-Kong.
Lowe, Edward, Manchester.
Lyon, John, Liverpool.
McDougall, Lionel John, London.
McIntyre, William, Bombay, India.
MacLennan, Alexander, M.I.Mech.E., M.I.Mar.E., Kuala Lumpur, Federated Malay States.
Macready, William Robert, Liverpool.
Manchester Public Libraries, Chief Librarian of, Manchester.
Mann, Sidney George Norman, London.
Mansfield, John F., Hull.
Milne, Professor David, B.Sc., Lyallpur, India.
Moore, James Robert, Bombay, India.
Nadin, Joseph, Oldham.
Nutting, Henry William Walter, London.
Oram, Ashley Edward, London.
Padmore, George, Gayton, Northants.
Parkinson, Stephen Herbert, St. Anne's-on-the-Sea.
Parr, Edwin Louis, London.
Parsons, George, London.
Pedley, R. Denison, F.R.C.S.(Edin.), L.D.S.(Eng.), London.
Pentecost, Harry, Truro.
Phillips, Fred P., London.
Phipps, Charles William, Northampton.
Pillay, N. K. Padmanabha, Leeds.
Pycroft, John, Nottingham.
Ralls, George Edward Durston, Birmingham.
Reece, J. Graham, M.I.A.E., Liverpool.
Reid, Andrew Thomson, D.L., J.P., Auchterarder, Perthshire.
Reynolds, Richard, Sheffield.
Roff, Walter, Stavanger, Norway.
Sadler, Stanley Aubrey, Eaglescliffe, Co. Durham.
Saint, Henry Bell, Newcastle-on-Tyne.
Salvesen, Lt.-Col. Theodore Emile, F.R.S.E., Edinburgh.
Sharman, Philip Alan, Hitchin.
Shave, George James, London.
Sheldon, John Eccleston, Birmingham.
Shepherd, A. F., Halifax.
Silley, John H., London.
Smith, F. Hindley, Southport.
Sole, Alfred George, London.
Sonn, L., London.
Stanley, Edward John, Peterborough.
Steane, George Arthur, Coventry.
Stedman, William, San Francisco, U.S.A.
Stirling, Robert, London.
Swinburne, Thomas Harvey Morgan, A.M.I.E.E., Altrincham.
Tacey, Francis Ernest, London.
Tearne, Frank Ernest, Birmingham.
Timotheieff, Basil T., B.D., M.A.I. (Petrograd), London.
Treble, Henry, London.
Tucker, John Bristow, Birmingham.
Walker, Alexander, Troon, Ayrshire.
Walker, Harry, J.P., M.I.E.E., M.I.Mech.E., Gateshead-on-Tyne.
Walker, Henry, F.C.S., M.S.C.I., London.
Walls, Ernest, Bristol.
Walston, Sir Charles, Litt.D., Ph.D., Cambridge.
Warner, Herbert George, London.
Watson, Owen William Joseph, M.I.A.E., A.M.I.Mech.E., Stafford.
White, William Lamb, Birmingham.
Williamson, William Dean, Wigan.
Wilson, Talbot Edward Baines, J.P., Sheffield.

The CHAIRMAN delivered the following

ADDRESS.

It is gratifying that I am able to report that the Society, at the opening of its 165th Session, is in a flourishing and vigorous condition.

Although it did not suffer from the war so seriously as was at one time apprehended, the Society did, of course, lose a certain number of Fellows. It now seems permissible to hope, however, that the worst is over. Last session 375 new Fellows were elected, as compared with 163 in the previous twelve months; and if the present rate is continued the figures of 1919 should show a decided increase over those of last year. To-day 156 new Fellows have been proposed; at the opening meeting of last session the number was 62.

There has also been a satisfactory rise this year in the number of entries for the Society's examinations, which exceeded 31,000, as compared with 26,000 in 1917; and there will probably be a further substantial advance next year, as the Council, at the request of the War Office, have arranged to hold special examinations for troops on active service in February.

In addition to the usual work of the Society, the Council, in conjunction with the Arts and Crafts Exhibition Society, the Design and Industries Association, and the London County Council Trade Consultative Committees, have during the last year devoted much attention to the question of improving the artistic qualities of British manufactures. As a result of this, a meeting was held here on October 28th, presided over by the Right Hon. H. A. L. Fisher, M.P., President of the Board of Education, and attended by a large number of representative manufacturers, distributors, designers, craftsmen, and others

Two schemes—one formulated by the Society, for the Promotion of Industrial Art, and the other by the Board of Trade, for the Establishment of a British Institute of Industrial Art—were submitted to the meeting, and a resolution was passed approving the issue of a joint appeal for funds on behalf of the two schemes. It is earnestly hoped that the appeal may meet with a generous response, and thus enable the Society to do its share in an important branch of national reconstruction.

A programme has been arranged for the forthcoming session which does not, I think, fall below the high level attained in former years, and should help to add to our numbers by attracting new Fellows. At the same time I would urge that all Fellows should make the work of the Society known among their friends, and so secure more supporters, and enable the Society to extend its activities.

Science and the Future.

Your Council having done me the honour of electing me for a second term of office as their Chairman, it is my duty once more to deliver to you an Address on the occasion of the opening of this new session. Last year, in speaking to you of Science and its Functions, I endeavoured, by means of a rapid sketch of its origins and its progress in the past, and by some considerations of its scope and effects in the present, to show how important Science is, and how largely mankind is dependent upon it for our modern civilisation.

This year I propose to advance a step farther, and perhaps with more daring than prudence, to consider some aspects of Science and the Future, together with what we may possibly expect, just in one or two directions, in the days that are still to come.

A matter which we now see constantly referred to, in every newspaper and by many public speakers, is what is known as reconstruction—that is to say, the putting of our affairs in order after the finish of the war. Now, undoubtedly the war has been responsible for an enormous amount of destruction of capital; but when estimates are given, as they constantly are given, of the percentage of loss in Belgium, France, Italy, Serbia, and other countries, it is not usually borne in mind that Capital does not merely consist of gold and silver, of bricks and mortar, of furniture and fitments, or even of railways, steamships and machinery—mostly things that in process of time fall into decay—that the main Capital of the modern world does not consist of the concrete constructions of labour or of material things at all, but of scientific knowledge. If we could imagine such a catastrophe as destruction, on the scale that has recently taken place in the fighting zones, spread over the whole civilised world, so that nothing was left anywhere at all of the material handiwork of the past few hundreds of years, this would not necessarily mean the relapse of mankind in general to the savage state of our prehistoric ancestors, who lived before the accumulation of our present priceless scientific knowledge had even begun. That this is so we see clearly from the lessons of the past. For thousands of years the manual labourer has been at work, and untold have been the products of his toil. How many of these products, however, have come down to the present day? Where are now the splendid constructions, the magnificent buildings, the costly and varied manufactures, of ancient Babylon, Egypt, Greece, and Rome? A few scattered fragments, of a purely antiquarian interest, but of no utilitarian value, are all that are left. The greater portion have entirely disappeared. But not so the products of the ancient mind. These to a large extent still endure. For all our industries, all our arts and crafts, and all our sciences have their roots in the distant past. Some knowledge of importance may, in the crash of empires and the great social convulsions that have taken place, have been lost or forgotten, but comparatively not much; while, owing to the invention of printing, and the consequent easy multiplication of records, this is never likely to happen again, at any rate on any considerable scale. Thus to reconstruct the material things now temporarily destroyed will take only a very small fraction of the labour that had to be expended, or of the centuries of time that had to pass, while, by slow degrees and arduous effort, man learnt how to bring all these things about. For the mere construction of the material paraphernalia of civilisation is in value as nothing to the knowledge of how to construct them. Taking this into consideration, we recognise the fallacy of the Socialist's doctrine that all wealth is due to manual labour, and we see how little of the Capital of the world is really due to mere handiwork, however skilled, and how much to the mental efforts of exceptional men, who through countless generations, by their investigations, discoveries, and inventions have rendered possible all our wonderful possessions. When, therefore,

we compile estimates of the losses due to the war let us not forget that our greatest asset, the vast store of knowledge that Science has gathered together, for us the heirs of all the ages, is still intact. It is a store that has slowly been accumulating ever since the beginning of the world, a store which enables man more and more to triumph over Nature, and one that for ever remains practically indestructible as the real permanent Capital of the race, and by far its most precious heritage.

Now, though the devastation due to the war will in time be readily enough repaired, and this without any call for new scientific invention or discovery, it is otherwise with the general future. Though the doctrine of Malthus —that whilst the population increases in geometrical ratio, the supply of food only increases in arithmetical ratio—is now discredited, the war in fact has shown us how nearly the world lives up to its supply of food and other necessaries, and how disturbances, such as those that the war has occasioned, may lead to the disappearance of the little margin that there is. Were it not for the aid that Science already affords to agriculture—in mechanical means of cultivation, and in methods of irrigation, fertilisation, and the like, together with facilities as regards transport and countless other matters—neither a country like this, nor the whole earth, could even now support their present populations; whilst in the future, as human beings increase still further, the stress will be accentuated. It is stated in no less reliable a handbook than *Whitaker's Almanack*, that "it has been estimated that the earth can maintain a population of 6,000,000,000 souls, a total which will be reached about A.D. 2100 at the present rate of increase." I have been unable to obtain the foundation for this statement, but if it is correct the urgency of the matter is obvious, much more pressing indeed than the question of the exhaustion of our coal that is so often mentioned, and with regard to which I shall have something to say later on. For if once the stage were reached where the population increased more rapidly than the means of its sustenance, then either by famine or by reduction in the reproductivity of the race, addition to the population would have to be checked, and it is difficult to believe that either Leagues of Nations or anything else would have the power to prevent conflicts between peoples struggling in dire necessity for the vital means of existence. Such conflicts have no doubt taken place locally in the past history of our globe, and it is for Science to prevent, or delay as long as possible, if it cannot eventually preclude, the world-wide repetition of such disasters. Anyway, whether we are dealing with present-time requirements or with those that are more remote, the shortage of the necessaries of life and of civilisation that is bound to grow in extent, *vis-à-vis* of the increase of the population of the world, can only be met by new achievements in the way of scientific discovery and invention, and by improved and more scientific organisation.

As time goes on all industries must tend to become more intricate and elaborate, and more and more dependent for success, on the one hand upon the skilful management of the specially trained, and on the other upon the general mass of the workers intelligently and cheerfully submitting to the technical direction of minds more gifted than their own. This applies to the educated workers as well as to those who are uneducated.

Luckily the need for scientific brains is at last becoming recognised by every class, even by the Labour Party, and we are not now likely to see, at any rate in any civilised country, a recurrence of the attitude of the revolutionists of 1794, who sent the great Lavoisier to the scaffold with the gibe that the Republic had no need for chemists.

Thus in the future, if the industries of this country are to flourish in the face of the world's competition, it is above all things necessary that Science should play a greater part in them than it has had in the past. In most departments of industry the old rules of thumb are obsolete, and if they have not already been superseded the sooner that they go the better. The modern world has no room for antiquated and unscientific methods. But in arriving at the conditions that are desirable, manufacturers will require all the help they can get, and especially they should be able to look for assistance from the Government of the country. Much in this direction is, it is satisfactory to know, already under way. The National Physical Laboratory, which, under the direction of Sir Richard Glazebrook, to whom our Society has this year awarded its Albert Medal, is doing a great work in assisting technical industry. Until recently it has been carried on at the risk of the Royal Society, but is now to be guaranteed its requisite finance from Treasury sources. Similarly the Advisory Council has been furnished by the State with funds with which, in combination with manufacturers,

Research Associations are being instituted, for the purpose of carrying out scientific investigations useful to the needs of different descriptions of manufacturing trades. All this is in the right direction and will, it is to be hoped, be increased so as to operate on a still larger scale. Whatever sums, however large, the Government can be induced to spend in thus promoting the applications of Science to industry, provided the expenditure is wisely directed, will quickly repay themselves many times over by the increase of prosperity that they are certain to bring about. At the same time let us beware of Government control, which in the long run is almost sure to result in political interference, and consequent disaster. All experience goes to prove this, and not least the experience that has been gained during the past four years of war. Here, no doubt, under the spell of patriotic enthusiasm, and owing largely to the self-sacrifice of hundreds of our best brains, almost incredible things have been accomplished in the huge munition factories that have been organised by the State. The cost, however, has been prodigious, as also the waste, and while such procedure is justified in order to meet the exigencies of war, in times of peace such arrangements could never prove economic, or stand for a moment the test of competition from other industrial countries. Whatever may be possible under war conditions, in ordinary times the incentive of personal gain cannot be dispensed with, while it is idle to compare production, on the scale and under the conditions that have recently obtained in munitions factories, with what can be looked for under ordinary trade conditions, where the expenses of finding and keeping markets—expenses that do not exist in the case of Government war contracts—have to be met. Moreover, while opinion is unanimous in advocating the advantages to be gained by the State doing all it can to stimulate and encourage the application of Science to industry, it is only necessary to consult the manufacturers of the country, who have had experience during the past few years of Government control, to obtain equally convincing evidence of the petrifying and sterilising effect of the latter, and how it hampers and, indeed, tends to kill enterprise at every turn. Time does not avail here to analyse the reasons, but even the most experienced and capable of business men seem to become paralysed both as regards initiative and as regards getting things done, when once caught in the tentacles of the bureaucratic machine. Hence when one sees advocated in the press, as has recently been the case, that certain key industries should be safeguarded by being placed under Government control, one can only hope that no such mischievous advice will ever be followed. By all means let there be Government assistance, but the less Government control the better.

Now to turn to a different subject. "If instead of a little smattering of Latin, which the children of the common people are sometimes taught . . . and which can scarce ever be of any use to them, they were instructed in the elementary parts of geometry and mechanics, the literary education of this rank of people would perhaps be as complete as it can be." Thus wrote Adam Smith in his "Wealth of Nations," and he proceeds to recommend the "instituting some sort of probation even in the higher and more difficult sciences to be undergone by every person before he was permitted to exercise any liberal profession, and before he could be received as a candidate for any honourable office of trust or profit."

This was written nearly a century and a half ago, and the controversy of Science versus the Classics is still with us. It is a final phase of the old controversy in connection with authority, chiefly the authority of Aristotle, but also of the Church, which did so much to impede the progress of Science throughout the Middle Ages. It is largely bound up with the matter of the subjects set in examinations, and dependent upon the vested interests of teachers and examiners, who, having themselves been brought up upon the Classics and knowing little or nothing of Science, are naturally disposed, in self-defence, if for no other reason, to inculcate the shoemaker's doctrine that there is nothing like leather. Signs are, however, now not wanting that at length the claims of Science in education are beginning to be recognised. The lessons of the war and the visions of industrial competition, keener than ever, that are already presenting themselves, are having their effect. Just as at the present day it is difficult for us to understand how the dictates of classical authority some hundreds of years ago put a bar to scientific investigation, so in the future it will be considered almost incredible that up to the second decade of the twentieth century the learning of dead languages and the study of their dry bones was considered a better preparation for an active career than the pursuit of living science, with all its practical application and its insight into the wonderful world in which we live. In putting forward,

however, the advantages for all and sundry of a scientific education, far be it from me to decry the study of classical literature as a relaxation, or even as a serious occupation, for the minds that are naturally drawn that way. By all means let us have a few great Classicists, just as we have a few real poets, though we can do without the smaller fry in both spheres. But for the ordinary person who wishes to refresh himself with the heroic epics of Homer or of Virgil, the subtleties of Plato, or the graceful fancies and the delicate diction of the Greek Anthology, let him do here what he already does, certainly with no loss, in the case of Holy Writ, and read the translations that have been made by great masters, which are assuredly much better than any he is ever likely to produce for himself. Nor, indeed, must I be supposed to depreciate the teaching of history or of foreign languages, and especially of our own—all matters of great importance even to the man who proposes to devote himself to a purely scientific career. For what I presume is intended to be the object of general modern education is first of all to impart such a knowledge to the average boy as will fit him to be a good citizen, and secondly to give everyone, in whatsoever station of life he may be born, the opportunity of development: in the early stages to the best extent of which he is capable, with proper chances and encouragements for the future later on, should he give promise of exceptional ability in any direction. The history of Science in the past is largely made up of the lives of men who were self-taught, but the groundwork of most sciences is daily becoming more intricate and abstruse, and consequently more difficult to acquire. What is necessary is the teaching of this groundwork, and then opportunity for expansion. We know, as I have said, of many instances of great scientists who were self-taught, but we know nothing of the others who might have been their equals had they ever, by a little rudimentary teaching, been started on the scientific road. As has been well said, "The literature of Science might have been quite different if Faraday had missed the unique opportunity afforded him by Davy at the Royal Institution. How many Faradays have remained mute and inglorious because doors were closed?"

There is one method of acquiring a scientific education to which, in my opinion, not nearly enough attention is paid. I refer to the private reading of technical books and of periodic scientific literature. In the past many of our leading scientific men have owed their education almost entirely to this method. Faraday was a bookbinder's apprentice, and obtained his first introduction to Science by reading the books that were sent to his employer to be bound. The first Lord Armstrong, who was the inventor of the hydraulic method of transmitting and utilising power, and was also the father of modern gunnery, had no advantage in the way of scientific teaching and, as he himself once told me, acquired his early knowledge of Science almost entirely by reading. Other distinguished scientists and inventors who educated themselves in this way were the Scotchman, Alexander Graham Bell, who has received the Albert Medal of this Society for his invention of the telephone, and Thomas Alva Edison, the renowned American inventor, who also has received the Albert Medal for the invention of the phonograph, and who, when a lad, was so voracious a reader that he is said to have started to read the "Encyclopædia Britannica" right through from end to end, though history does not relate how far he got with this ambitious project. There have also been many others who never had the advantage of any scientific teaching either at school or college, and yet achieved great distinction. No doubt these were exceptional men, but how many more such might there not be if greater facilities existed. It is not within the power of many young men to buy books to any great extent, and scientific literature is not only expensive but is notoriously ephemeral, becoming rapidly obsolete and comparatively valueless. Most of the large scientific libraries such as are possessed by the various engineering institutions and other scientific societies are only accessible to their members, who have to pay heavy subscriptions, and even then only during hours which to a large extent preclude their use by those who have to earn their livelihood, and have therefore little time but the evenings available for reading. Such libraries, moreover, only exist in London and in a few of the large towns. No doubt the war scarcity of persons suitable as attendants is in part responsible and makes any change at the present time very difficult, but I am convinced that whenever possible these libraries should be kept open on Saturday afternoons and in the evenings. Indeed, if necessary it would be much more useful to keep them open till, say, ten o'clock at night even if this necessitated their not opening at all till after mid-day. I put this forward from the actual experience

of students, members of some of our leading engineering institutions, who complain that their libraries are useless to them as they are only open at hours when they are perforce otherwise engaged. I am sure that some improvement is possible, at any rate after the war, in this respect; but what I am anxious particularly to put forward is the desirability of the establishment of lending libraries from which all the latest scientific works could be obtained under suitable arrangements. The Institution of Electrical Engineers has of recent years instituted such a lending scientific library, but only to its own members and on a comparatively small scale; but, of course, to be of any wide use such an arrangement must be on a large scale and throughout the country. It is suggested that something more in this direction might be done by the Patent Office, who have large funds available entirely derived from the fees paid to them by inventors. No doubt the Patent Office already provides a splendid library in London to which the public are freely admitted, but this might be supplemented by additional similar libraries, in all our large towns, with facilities for lending the books out by means of a special free postal service, on a system embracing the whole country. Anyway, what is wanted is to encourage self-education in scientific and technical subjects, so that those who have not the time or the opportunity to attend classes and lectures, or even to frequent libraries, where reading can only take place *in situ*, can improve their knowledge by reading at home in their spare time. It is impossible also to exaggerate the utility of public or semi-public lectures on scientific and technical subjects in spreading knowledge in these subjects and stimulating curiosity, thought, and also invention. Throughout its long existence the activity of the Royal Society of Arts in this direction is well known, and must have had a profound and widespread effect, not only on those who have been able to enjoy the advantage of attending the lectures, many of them by the highest authorities in their various spheres, but also of reading accounts of them in the *Journal*. In our case the object and the achievement have mainly been of a technical nature, applied rather than pure science being what this Society has chiefly in view. In pure science the lectures at the Royal Institution have undoubtedly been a stimulus to thousands, and the same may be said of the lectures in all the philosophical and scientific societies throughout the country. The ultra erudite are sometimes rather inclined to sneer at such lectures as popular and superficial, but it is exactly by such popular lectures that general interest in Science can be roused, rather than by the dryer and more strictly scientific dissertations that we expect at professional, scholastic and university institutions.

The importance of provoking an interest in scientific subjects is paramount, and once the interest is created those interested can follow matters up in particular spheres by special reading. What is wanted is to awaken a taste for scientific literature, after which the pursuit of the fairy tales of scientific discovery and invention will by many be found much more fascinating than the literary rubbish upon which so large a majority of the population fritter away their time.

Though, according to the testimony of experience, great inventors are born and not made, the creative power of inventors, at any rate in its highest form, being a natural gift which cannot be acquired by any amount of study, still with the increased spread of scientific knowledge that suitable education must bring about, invention is bound to benefit greatly. For one thing, persons gifted with inventive genius, who without scientific knowledge would only be able to apply themselves to comparatively simple problems, will, with the larger vision that a good scientific education will give, keep off the impossible projects on which some quite ingenious, but uneducated, inventors waste their energies, and will be anxious and able to tackle questions which otherwise would never have come within their purview. To this end, however, the education must be suitable in kind and not of such a description as by too much learning is apt to cramp originality. Again, with more knowledge persons may find that they possess inventiveness, who otherwise would never have made this discovery. As regards scientific research and discovery, the case is perhaps more simple, as much useful research can be carried on by persons who are destitute of any high degree of originative faculty—painstaking and methodical powers of observation, which can certainly be developed by training, being the chief requirements for much of the work. For great generalisation and discoveries of the first order, the highest degree of intellect will no doubt still be requisite, but it is hoped that with the increase of knowledge a greater number of persons will find that they possess these natural and unacquirable attainments.

There is a fallacious notion abroad that practically all great scientific work has been done by the poor. No doubt necessity is the mother of invention, and poverty in every walk of life often acts as a considerable incentive. So far as the facts are concerned, however, let us remember that at least two of our greatest scientific discoverers, namely Robert Boyle and Henry Cavendish, were the possessors of great inherited wealth, and that there are other instances of a similar character. Indeed, but for their wealth and the leisure that they thereby enjoyed, not a few of our most eminent men of Science would probably never have brought their labours to fruition, while there are many instances of inventions that could only have been made by persons who had the command of much money. James Watt could never have accomplished what he did without the wealth of his partner Boulton, and to come to more modern times the development of the steam turbine, which entailed years of costly experimenting without any adequate financial return, is another case in point. It is the old story of one man's meat being another man's poison. Some temperaments require the spur of necessity to make them exert themselves, while for others the grinding task of providing daily sustenance for themselves and their families suffices to exhaust their energies and leaves nothing for other endeavour. In the literature of Industry we frequently come across accounts of the poor inventor who, though almost starving, by superhuman endurance and perseverance eventually achieves success. We hear nothing, however, of the countless others in whose cases, "Chill penury repressed their noble rage, and froze the genial current of the soul." If poverty may be deleterious in the case of individuals, it is still more so when we come to consider larger units such as whole industries, and there can be no more sure fact than that no industry is in a healthy condition, or is likely to advance and increase, which does not make good profits.

Just as John Stuart Mill feared that the limited number of notes in the audible musical scale would in time lead to the exhaustion of all possible melodies, so there have been those who have thought that scientific discovery would before long come to a stop owing to the dearth of subject-matter and to the limitations of the human intellect. Whatever may be the fact in regard to music, nothing could be more erroneous than this idea in respect to Science, for the reason that every new discovery and invention opens up the path for others, and thus the scientific horizon surely widens year by year. Indeed, so far from discovery and invention being likely to come to a stop, both are sure to extend at a rapidly increasing rate, particularly if we have more Science taught to young people and greater encouragement given to scientific workers with consequent additions to their numbers. In the comparatively new fields of radio-activity, electro-magnetic radiation, synthetic chemistry, chemical catalysis, electrical osmosis, photo-electricity, and corpuscular matter, to mention at random only a few of those that readily occur to one, the prospect seems practically illimitable. Moreover, new materials with new properties, whether elementary substances such as the new gases—Argon, Helium, Krypton, Neon, and others; the so-called rare earths—Thorium, Cerium, Yttrium, Scandium, and the rest; or new alloys and compounds which chemists and metallurgists keep providing for particular purposes, afford fresh means for pursuing research. We have also new mechanical appliances of all sorts, and new methods which enable us to obtain on the one hand, in the electric furnace, temperatures approaching in heat to that of the sun, and on the other hand in special refrigerators to cold quite near to that of space and of the absolute zero—temperatures both high and low, quite beyond reach only a few years ago. Again we have learnt how to apply prodigious mechanical pressures and how to obtain gaseous vacua on unprecedented scales. We can produce and employ electric currents and pressures, and both electric and magnetic fields, of intensities previously unknown, and measurements of all kinds can be made with a delicacy and an accuracy almost beyond belief. The number of these things is much greater than there is time to record here, and their importance is intensified by the fact that each reacts on the others with the production of more, so that the tools and agents at the disposal of research are continually being added to. Nor, if we turn from pure science and its possibilities and means for discovery to inventions and the science that is applied to utilitarian uses, is the case in any wise different. Here again the effects are cumulative, both discovery and invention assisting to bring still further invention within our reach. The petrol engine, originally invented for propelling boats, and later adapted to driving land vehicles, has rendered possible the conquest of the air by the aeroplane, as also the depths of the sea by

the deadly submarine. Bell's telephone, that instrument of almost sublime simplicity, which, as originally produced, was intended for transmitting speech, is now used for receiving the inarticulate signals of wireless telegraphy, which could hardly have reached its present development without it. Photography and its sensitive plates and papers are now applied in radiography and in other directions of which the original photographic inventors never dreamed. The metal cerium first brought into notice by its being a necessary constituent of incandescent gas mantles, now in pocket lighters helps the smoker in these difficult times to dispense with matches. The vacuum jacket, invented by Sir James Dewar for keeping liquid air cold, is used to-day for keeping things hot. Radium, which when discovered by Madame Curie was only a scientific curiosity, has many applications in medicine, and is now used to illuminate watches and instrument dials so that they can be read in the dark. The gyrostat, which is a development of the child's spinning-top, and used to be merely a scientific toy, is now the foundation of a description of ship's compass, which points to the true and not to the magnetic north pole of the earth, and without which the navigation of submarines would be almost impossible. Tungsten, which a few years ago was unknown in true metallic form, now constitutes the filaments of all our incandescent electric lamps, while the discoveries of Crookes, J. J. Thomson, and others in connection with rarefied gases have rendered possible the so-called half-watt lamp of surprising efficiency. By an electric process as old as the time of Cavendish, who discovered it, nitrogen from the air is now being extracted to make nitrates so necessary for agricultural fertilisers and for explosives, which latter have their uses apart from their application to warfare. The cinematograph of the modern picture palace has been developed out of the old Wheel of Life of the days of our childhood. Indeed the list that could be compiled is almost endless.

One of the most interesting of modern inventions is that of wireless telegraphy, and it is also one which appears to present great scope for improvement and extension. There is a mysterious fascination that captivates the imagination about these wireless signals, which come over hundreds and thousands of miles of space without any visible or tangible means of connection. Yet, as a matter of fact, they are in nowise more wonderful than telegraphy by wire. Indeed, had, as might quite have been possible, the wireless method been the first to be discovered, then our wonder would have been excited at the ease with which by means of a wire of minute section, the signals could so easily be conveyed over prodigious distances in any direction to any required point. For the wireless system is really analogous to the uproarious fog-horn, whose signals are sent out far and wide in all directions, for all who have ears, and are within range of the sound, to hear; while wire telegraphy more resembles the speaking-tube, whereby much smaller sounds are conveyed from the speaker to a particular listener at the other end.

Now during the past five years the improvements made in wireless telegraphy, and also in wireless telephony, have been very important, but as yet it is not admissible to discuss them; besides, my subject is rather the future than the past. One matter, however, is within public knowledge, and that is the increased and still increasing amount of news that we get in the papers that appears under the heading of "Per Wireless Press." Indeed, wireless telegraphy appears to be developing at last in what has always appeared to me to be its proper field, which is not so much to communicate between one individual and another, but rather for the communication of intelligence broadcast over the earth, "Urbi et Orbi"—to the city and to the world—to borrow from the famous wording of the Papal benediction from the Loggia of St. Peter's in Rome of bygone times. No doubt maritime wireless communication between ships, and between ship and shore, hitherto its most useful application, is another case altogether, and supplies a want that telegraphy by wire cannot meet at all. With this we are already familiar, while the use of wireless as a voice that can speak simultaneously to points on every portion of the earth is in some ways a more novel proposition.

No doubt some persons who had private wireless stations of their own before the war, were used to getting time signals from Paris from the Eiffel Tower, and from Nauen in Germany; while a few of those who had mastered the difficulties of reading the Morse alphabet by ear, were able to decipher weather reports from these places, as well as from our own Admiralty, in addition to general news from Poldhu in Cornwall, and from one or two other large stations.

What I have in my mind, however, goes much farther than this. In London tape and

column-printing telegraph instruments operated by wire, that record sporting, parliamentary and general news, have long been familiar objects in clubs and hotels, and have become a portion of our daily life. Now there is no reason at all why similar printing instruments, which he who runs can read, should not be operated by wireless means, not only in London and other large cities, but throughout the country, or even throughout the world. Special transmitting stations using different wave-lengths could send out the messages, while separate printing machines, tuned each to respond to the wave-length of a particular transmitter, at each required point, would receive and record them. No connecting wires, costly both as regards first expense or as regards upkeep, would be required, but only suitable aerials at each transmitting and receiving station.

Some regulations would be necessary to prevent interference, and as wireless waves, travelling as they do through the ether of space at the enormous speed of 186,000 miles per second, recognise no international boundaries, they would have to be universal. Thus arises a fitting opportunity for the League of Nations. For the distribution of news to the press nothing could be better or more economical, while there is no reason why clubs, hotels and private houses everywhere should not also be thus supplied with the latest intelligence. For in wireless telegraphy it costs no more to send signals to a thousand receiving stations than to a single one, and there is practically no limit to the number of the stations that can simultaneously receive signals from a single transmitting station. To some, this sketch of the universal distribution of news to all and sundry may appear fantastic, but it is not really so at all; for, at any rate as concerns an area no larger than Western Europe and the British Islands, it is well within the range of practicability at the present time, and only requires a little working out to arrive at the best arrangements. Nor is this all: spoken words of the human voice have already been intelligibly transmitted by wireless across the Atlantic between the United States and Paris, a feat that has never been accomplished by cable; and there is no reason that I am aware of, why, in the near future, we should not have a public speaker, say in London, in New York or anywhere, addressing by word of mouth and articulate wireless telephony an audience of thousands scattered, may be, over half the globe.

Great things are at present being foretold as to the marvels that we are to see in the way of the electric distribution of energy throughout the whole country from a small number of giant generating stations. Indeed, the subject is considered of sufficient importance to be mentioned in the Prime Minister's election address, which in itself is surely a sign of the times. The hope is held out that electric energy is thus to be so cheap that it will supersede every other kind of energy, not only for driving our mills, our machinery and our railway trains, but also universally for cooking, heating and other domestic purposes. Great improvement over our present parochial methods—according to which Parliament, in its wisdom, has divided up the country into an enormous number of absurdly small municipal electrical areas, which are far too limited in consumption for any reasonable economy to be obtained—is no doubt possible, but let us not be too sanguine. Some of the highest and most experienced authorities are of the opinion that the limits of economical generation and distribution are already being reached in the case of some of our larger systems, and that when we get above tens of thousands of horse-power, the step to hundreds of thousands does not effect more than a small percentage of saving, either in first cost, or in cost of working. There is also the question of material for the distribution conductors. Excepting silver, which of course is out of the question, pure copper, which is almost as good as silver, is the best electrical conductor we know of, and the amount of copper in the world is of course limited. No doubt by raising the electrical pressure, the amount of energy conveyed through a given conductor with a given loss, can be largely increased. But again there are limits to the endurance of insulating materials that can be obtained at a reasonable cost, though perhaps there is more obvious scope in regard to this than as regards increasing the conductivity of conductors. In a recent speculative article of American origin by Dr. J. A. L. Woddell, I notice that the writer prophesies the discovery of an alloy of ten times the conductivity of copper, but, so far as we at present know, all alloys have a worse and not a better conductivity than their elementary constituents; and though, so far as I am aware, no special investigation has ever proved that this is a natural law that cannot be overcome, still conversely there are no data to show that improvement can be looked for in this direction.

True, Dr. H. K. Onnes, of Leyden, has not long ago shown that, by reducing the temperature of metals to the temperature of liquid helium, or to within less than 4 degrees of the absolute zero of temperature, or more than 450 degrees below zero Farenheit, these lose practically all resistance, and become nearly perfect conductors. Under these conditions an electric current, once started by an electromotive force applied to a cooled mercury ring, was found to persist for hours after the electromotive force had been removed—truly a startling effect, and one calling to mind Ampère's theory of permanent magnetism, according to which the magnetism is supposed to be due to molecular electric currents that persist indefinitely. Still, even to those most anxious to do their best to believe in the wonders of the future, the cooling of electrical conductors by passing through them streams of liquid helium, in the case of the thousands of miles of such conductors that are requisite for electrical distribution, does not appear to be a very practicable proposition. However, results like those obtained by Onnes give one furiously to think, and there are other solutions that are possible though at present far from within our grasp. For instance, no one knows what improvement is yet to be obtained in the conductivity of metals by further purification, and especially by freeing them entirely from occluded gases. Electrolytic copper, which is specially pure, has already a conductivity measurably in excess of what was obtainable by the older methods of refining, while it has been found that in the case of palladium the extraction of the occluded hydrogen materially improves the conductivity. Possibly similar treatment might lead to important results with other metals. The subject is still largely unexplored, but if any practical method could be devised for diminishing the resistance of conductors, it would be a most important matter, as the enormous amount of copper at present required for any very large and widespread scheme of electrical distribution presents a very real difficulty.

It would also be rash to deny too absolutely the possibility of the wireless transmission of electric energy in bulk. The fact that enormous quantities of energy come to us in this way from the sun, with a transmission density that near the sun's surface is immense, shows what the ether is capable of doing. The production of plane waves would help the solution of the problem, but there is the difficulty of so concentrating and directing the waves that they may all be received on a limited area. Perhaps, however, it may be found that though electromagnetic waves cannot be driven to go exactly and only where is wished, they can possibly be led there. It is a problem at present beyond our ken, but so many marvels come to pass that one can never be sure of what may be brought about, provided always that no natural law stands in the way.

The economical generation of electricity from coal is however not merely a question of the scale upon which the operation is conducted, important up to a point though that condition is. In addition to its heat or energy giving properties, coal contains a number of constituents of great value, such as the tar from which the aniline and other dyes, and many other chemical products most useful in medicine, photography, and in the arts, are derived, together with toluol for explosives, benzine and other derivatives, including sulphate of ammonia, which is in great request as an agricultural fertiliser. Where the coal is simply burnt in a furnace, as in ordinary steam-boiler practice, all these are lost; but when it is first turned into gas these most valuable by-products, which are nowadays the chief stand-by of the gas industry, can be saved and turned to account. Up till now it has not been found economical to apply this refinement to electrical generating stations except in rare instances, but with larger stations and ample capital, and more especially with coal at increased prices, it is to be hoped that something in this direction may be found practicable on an economic basis, while it is even possible that it may be found necessary for the State to declare such preservation of the by-products imperative and make it compulsory. Furthermore, in electrical generation there is the very important matter of what engineers call the load factor, by which is meant the ratio of the actual amount of electric energy that a generating station supplies, to the amount that it could supply were it always working at full power. Lighting, and even ordinary motive power requirements, only last for a few hours in every twenty-four, so that while generating machinery has to be provided, sufficient to deal with the maximum load at any one moment, in many cases a large proportion of the machinery is not required, and has to stand idle for a considerable portion of each day. As interest on the capital that the machinery represents is mounting up all the time, and as there are many costs of labour,

and of fuel, which are not diminished in proportion as the load becomes a minimum, this is obviously very uneconomical. This is particularly so because with electricity, unlike gas, storage on any large scale is too costly to be practicable. It is thus most important, in order that electricity should be generated cheaply, that the gaps in the load should be filled up and the latter brought up as far as possible to a uniform maximum. With small stations, supplying limited areas, this is difficult if not impossible to attain, but where the supply is on a large scale, and distributed over a wide area, the diversity of uses at different hours of the day tends to equalisation, and assists the production of a load that corresponds more nearly to a steady one throughout the twenty-four hours and during every day of the year. This is the explanation of what many people fail to realise the reason for, namely, the difference in prices that the consumer has to pay for electricity for lighting, which, as stated, has usually only a short hour demand, and for heating and motive power purposes, where the hours of consumption are usually much longer. It is also to be hoped that the establishment of electro-chemical industries which take a continuous steady load, or better still can arrange to take energy only at such times as it is not required for other purposes, will assist in regulating the consumption so that generation can be carried on continuously at a maximum rate with a minimum of cost. These considerations are, of course, a commonplace to all electrical engineers, but they are not perhaps understood as well as they should be by the public.

By far the most important requirement of mankind is energy in its various forms. Like all other animals, man could not continue to exist without a constant supply of the energy which is requisite for the internal processes of his body, for the work that he does with his muscles and for the activities of his brain. It may be potential energy in the form of food, or kinetic energy such as he derives directly by conduction and radiation from his surroundings. Like the steam engine he must be stoked with fuel in order that he may develop mechanical power; and in order that he may exercise mental effort, like Babbage's calculating machine, he must be supplied with the equivalent of the energy required to turn the handle of that ingenious apparatus.

Nearly all our energy comes to us directly from the sun, though some portion is derived from the internal heat of the earth, and from terrestrial and lunar rotations. Moreover, what we get from the sun is transmitted to us from across the nearly ninety-five million miles of intervening space by waves in the universal ether exactly analogous to those we use for wireless telegraphy. Some of this sun energy goes to warm the earth and its atmosphere and our bodies, some is radiated away again into space, and some very small portion is stored in such a way that we are able to make use of it as we want it. The sun, whose temperature is about 6,000 degrees Centigrade, is constantly sending out some 9,000 horse-power per square foot of its superficial surface, and as the diameter of the sun is about 865,000 miles, there are a great many square feet, so that the amount of energy the sun radiates is prodigious. As the energy is sent out more or less equally in all directions, only a very small proportion of the whole is intercepted by the earth, but even so there is no lack in the supply that the earth receives, which amounts in total to some 200 billion horse-power, or on the average to some 4,000,000 horse-power per square mile of that portion of the earth's surface that is exposed not too obliquely to the sun's rays. All our water power, except any that may be obtained from the tides, and what small amount of power we can get from the wind, are of course purely solar in their origin, being due to the results of evaporation and of the thermal dilation of the air. But apart from the direct heat we get daily from the sun, our main source of energy is of course coal, which has been called bottled sunshine, and consists of vegetable growth in which is stored energy received from the sun during millions of years, millions of years ago. Energy from the sun is still being stored in all plant life, but according to Nernst only to the extent of about three millionths of the total that reaches the earth. Moreover it is by no means an efficient process, most of the energy that falls on the leaves being absorbed in evaporation or otherwise lost, and the actual amount of energy stored, as measured by Dr. Horace Brown, is less than 2 per cent. of what reaches the vegetation. For our food this will no doubt suffice for many a millennium, especially with the intensive culture that Science can provide, but when we come to consider fuel for warming our bodies, for driving our machinery, and for industrial purposes generally, we must bear in mind that the amount of coal in the world is strictly limited. Many estimates have been made of its duration, but not only

are data as to the amounts existing and available uncertain, but it is also difficult to foretell the rate at which consumption will increase. Anyway it runs into five or six hundred years for this country, and perhaps nearly ten times as long for the whole earth. Sooner or later, however, it will all be used up, and mankind will have to depend, no longer upon the stored energy of bygone aeons, but on the sun's actual daily supply. Economy in the consumption of coal is therefore a matter of great importance, especially in this country, where so much depends upon its use, and it is with this view that the present proposed large schemes for the economical generation and distribution of electric power have been put forward. Unfortunately nothing better than the heat engine, which includes all those engines that are operated by steam, gas and oil, bounded as its efficiency is by the laws of thermo-dynamics, has hitherto been discovered to turn our coal and oil into mechanical work. Other methods which are not so bounded, and in which, instead of a maximum of perhaps 30 per cent., nearly a cent. per cent. transformation could possibly be obtained, are theoretically conceivable, but do not materialise. Methods on the principle of Groves' gas battery, which gives electric energy directly from the oxidation of hydrogen, and others in which solid carbon is used as the oxidised element in a primary electric battery, were at one time considered hopeful, but have accomplished nothing; while some years ago considerable stir was made by a primary battery. invented by Dr. Borchers, of Aachen, which was supposed to derive its energy from the oxidation of carbonic oxide to carbonic acid, but which, like some other German projects, proved unsound both in theory and in practice. Then there are quite other methods of converting heat into work, as, for instance, our old friend the thermopile. This has, of course, proved up to now a most ineffective appliance, and some years ago Lord Rayleigh showed that with the materials then used, but only in the special case of their use, it was of necessity inefficient. Has anyone, however, of late years investigated the thermo-electric properties of all the new metals that the electric furnace, and other novel metallurgical processes, have recently provided, and of the alloys that these will make, and does anyone know how thermo-junctions, made of these or of the older materials, whose properties we are acquainted with at ordinary temperatures, would behave at temperatures so low that, as we have seen from the work of Onnes, all electrical resistance virtually disappears? All that can be said is that here are problems for the physicist and chemist which have great possibilities, if only they are investigated and solved whilst there is still plenty of coal left to be utilised. Seeing that the steam engine itself is not much more than a century old, and most of our electric knowledge is much younger, we need not perhaps despair even of this.

The importance of utilising the water power on the earth as a means of saving the consumption of coal is now thoroughly recognised, and is receiving the attention of the Governments of this and other countries. The amount, though large if everything available were utilised, is however insufficient to take the place of coal, while much of it exists in places remote from industries and population. This is without taking into account the power of the tides, which is enormous, but it would appear, impossible to turn to practical use, in most places on any large scale, except at a cost which is altogether prohibitive. There is also the internal heat of the earth, which is actually at present being utilised near Volterra in Italy, where volcanic steam issuing from the ground is being successfully applied to work two 5,000 horse-power turbines. This is a method which may perhaps be capable of considerable extension in various suitable parts of the earth, where volcanic forces come up to the surface, and are not too destructively active, but even so, the total amount of energy likely to be obtained in this way is comparatively insignificant. There is also the question whether, if, as some suppose, mineral oils are produced in the bowels of the earth by the action of superheated steam on the carboniferous rocks, this process is still going on at any useful rate so as to maintain the supply. Any evidence that there is appears, however, to be against this supposition, for all the older oil-fields of the United States already show signs of becoming exhausted, while it is by no means certain that oil, like coal, is not a product of solar radiation stored over vast periods of time, and, anyway, the quantity of oil that appears to be obtainable is only a very small amount compared with coal.

When therefore the coal is exhausted it would seem that in the main resource will have to be had to the enormous flood of solar radiant energy that is continually falling on the earth, and the problem is how this can best be utilised. The most obvious method is of

course to grow plants, stimulating them in every way that Science can devise, and cultivating especially those which grow most rapidly and are specially suitable for the production of fuel. Such fuel need not, however, take the crude form of mere firewood, but more likely it will be best to cultivate plants that store the solar energy in the form of starch and sugar which can be converted into alcohol, as is already being done on some scale in order to supplement petrol for motive purposes.

As, however, vegetation is, as we have seen, an exceedingly inefficient accumulator for the storage of solar energy, and as there is the further inefficiency of the heat engine to be taken into account before mechanical power can be realised, there arises the question whether Science cannot devise some more efficient and different method of converting solar radiation into work, leaving altogether on one side the organic world and the means that plant life affords. Solar engines, in which the heat of the sun's concentrated rays in tropical climates is employed to boil water or other more volatile liquids, and thus operate steam engines, are by no means new, but owing to their considerable first cost per horse-power, and their great cost of upkeep, have never so far proved commercially practicable, even where coal is exceedingly dear. They also suffer in an extreme degree from the limitations of all heat engines, inasmuch as they cannot take proper advantage of the extremely high temperature of the sun, but have to work at a much lower temperature, which implies degradation of the energy and loss. But happily solar heat engines do not exhaust the possibilities of the case, as there remain other methods which, though still in the womb of the future as regards being worked out, can yet be indicated, and with regard to the success of which there is no inherent improbability. Photo-chemistry is usually associated with the art of photography, but really embraces a much wider field, the potentialities of which have as yet been but very imperfectly explored. The direct transformation of radiant energy into chemical, or even into electrical energy, is by no means impossible—indeed, as we have seen, the former transformation is already effected, inefficiently it is true, by plants; while it also takes place on a small scale in all photographic processes where light causes chemical reduction. Becquerel, in France, showed some fifty years ago how radiant energy could be transformed into electrical energy, and Minchin, in England, and others have also done the same by different methods. There do not appear to be any theoretical objections to success, nor to much higher efficiencies being obtained in this way than by organic means. No doubt the laws of thermo-dynamics apply to all photo-chemical action, but as the temperature of solar radiation is so very great this is of no large importance. Here then in photo-chemistry, perhaps in photo-electric chemistry, we have probably the most important problem that the Science of the future has got to solve.

Of late, in the world war, on many a stricken field, our own and our Allied Armies have been overcoming our adversaries and subjugating the powers of evil. In the future may we hope for conquest in even a wider realm. From now, let us look forward to the further triumph of Science over the forces of Nature, and to the bringing of these forces still more into subjection, for the common service of mankind, for—

"Peace hath her victories
No less renowned than war."

After delivering the address, the Chairman presented the Society's medals, which were awarded for papers read during last Session.

At the Ordinary Meetings:—

W. Lawrence Balls, Sc.D., "Examples of Applied Science in the Cotton Industry."

George Martineau, C.B., "Sugar from Several Points of View."

Professor J. Bretland Farmer, D.Sc., F.R.S., "The Rubber-Planting Industry."

Martin O. Forster, D.Sc., F.R.S., "Organic Chemistry in relation to Industry."

In the Indian Section:—

H. M. Surtees Tuckwell, M.I.Mech.E., "The Tata Iron and Steel Works."

In the Colonial Section:—

Sir Walter Egerton, K.C.M.G., LL.D., "British Guiana and the Problem of its Development."

Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., in proposing a vote of thanks to the Chairman for his address, said he should have wished the task had fallen to someone who was better informed on the special subjects with which the Chairman had dealt, as, having been born eighty-two years ago, he himself belonged to a pre-scientific age. But even to a man like himself the address was full of interest and promise; it was stimulating and fertilising. The Chairman had recounted what had been, and from that he deduced "the earnest of the wonders that shall be." Mr. Campbell Swinton had already given up one year of his time and activities to the Society as Chairman of the Council, and nobody

who had not been behind the scenes knew how much interest and care he had devoted to the Society's welfare. The Society was most fortunate in inducing him to give a second year to the work. During his first year's Chairmanship not only had the number of Fellows increased, but also there had been a large increase in the candidates for examination; and another fortunate thing was that, by the work of some members of the Council and the Chairman, the Society had succeeded in getting from the Government a return of income tax already paid for the last three years.

Sir Boverton Redwood, Bt., F.R.S.E., said that it was generally considered that the duty of a seconder was limited to the formal discharge of the function allotted to him; but there was one part of Mr. Campbell Swinton's most thoughtful, stimulating, and admirable address on which he would like to be permitted to say just two or three words. He desired in the strongest way, and as the outcome of personal experience, to support what the Chairman had said as to the undesirability of State control of industry, and he hoped that that point in the address would be emphasised and brought home to those who had the opportunity of bringing influence to bear in connection with the matter. By all means let there be Government encouragement, such as had been often looked for in vain in the past, and Government assistance such as had been referred to in the address, but let there be nothing in the nature of Government control of industry.

The motion was carried unanimously.

The Chairman briefly thanked the members for their vote of thanks, and the meeting terminated.

THE SHRIMP INDUSTRY AT MAZATLAN.

There are some forty or fifty shrimp fisheries along the Pacific shore line within the Mazatlan district, with the trading centre of the industry at Mazatlan. Most of the shrimp are collected during the rainy season—from July to November—in numerous shallow lagoons along the seashore. They are brought in from the adjacent waters of the Pacific Ocean by the currents. It often happens that there are large areas of the sea literally filled with them.

All lagoons utilised in catching the shrimp are traversed at the inlet by a dam with two rows of light piling about four feet apart, filled in with enough fine brush to prevent the shrimp passing through. Depending upon the length of the dam, one or more traps of the ordinary style of lobster trap are located at convenient intervals for allowing the shrimp to enter the lagoon, and at the same time for catching them when the fishermen are ready to take them from the water. When they first enter the lagoons from the sea they are usually small, although in some seasons they are large enough for immediate use.

The lagoons produce a weed or grass that grows from the bottom and is known locally as paiste. Immediately upon entering the lagoons, the shrimp begins feeding upon this weed so that in seasonable years the average length of the shrimp increases to about 4½ inches.

Unlike the ordinary species of fish, shrimp move with the currents of water in which they are found. Therefore the fishermen watch for the rising of the tide to open the entrances through the dams and the falling of the tide to close them.

When the shrimp have reached full growth in the lagoons the fishermen set their traps and again utilise the force of the tide, this time the outgoing one, in making the catch. At each trap, if there are men enough, one man uses a sort of basket fastened to the end of a pole with which to dip the shrimp from the trap and deposit them in a canoe. Generally several canoe loads are taken to camp by each man at each tide, making it possible for a few men to gather several tons in a day.

Many of the smaller operators in the shrimp industry catch with nets ranging from 100 to 400 ft. in length, either in the lagoons or in shallow water along the open seashore. When the shrimp season is good, as is usually the case, it is not uncommon for ten men to catch twenty tons of shrimp in a period of eight hours, using the hand nets. Of course, this success can be attained only on occasional days when the shrimp happen to drift within the scope of operations.

From a report by the United States Consul at Mazatlan, it appears that the shrimp industry of that district provides three forms of the preserved product for the trade, viz.: (*a*) Mexican shrimp, which is salt-dried, and so called because it is produced principally by Mexican fishermen, and used almost exclusively in the Mexican trade. It is packed in mat bags with the head and shell on, and is first in importance among the three products. (*b*) China shrimp, which is cooked with a little salt and then dried with the head and shell removed. It was so named because it is produced by the Chinese to some extent, and is prepared for the use of the Chinese in Mexico, the United States, and even in China. China shrimp is second in importance. (*c*) Canned shrimp, which is prepared for the market in the United States at a few small canneries located at points adjacent to the fisheries. All of the canning factories are operated by Americans.

One American concern that has been in the shrimp-canning business during the past four or five years, having a plant with a daily capacity of 5,000 tons, has taken steps to reorganise for the purpose of increasing its output to about 20,000 cans daily. In order to succeed in this industry a good knowledge of Spanish and of local conditions is required, together with ample capital. Catches will be lost if exposed to heavy

rains during the process of drying in the case of Mexican or China shrimp, or before the canned shrimp are put up, unless some method of covering is employed at a heavy cost. Another difficulty is the matter of gauging the number of labourers necessary to the success of the season or of the particular catch, as several thousand dollars may be lost in shrimp over-night if sufficient help is not forthcoming.

The shrimp industry, adds the Consul, appears to be in its infancy, and is conducted on a small scale in the Mazatlan district, handling only about 10 per cent. of the available supply.

INDIGO INDUSTRY IN SWATOW DISTRICT.

Greater attention has been given to the cultivation of the indigo plant since 1914. While actual figures are not available the increase in the area under cultivation in the Swatow district must be considerable, for exports show a marked expansion and much larger quantities have been used by the local dyers.

To make liquid indigo the indigo plant, after being cut and gathered, is first placed in casks, specially made with plugged holes in the side, which are filled with water. After soaking a few days lime is added, and in about one week's time the stem and branches of the plant are removed. Each day the contents of the cask, after being well stirred and beaten, are allowed to settle, and on the following morning, before this process is repeated, some of the plugs are removed, allowing the water above the sediment, which had formed overnight, to escape. Gradually the water is thus eliminated and liquid indigo is found in the bottom of the casks. These casks vary in size, some of them being as large as 12 ft. deep by 10 ft. in diameter, and are made of thick pine boards held together by bamboo hoops.

In recent years the exports of liquid indigo from Swatow have been as follows: 1914, 817 tons; 1915, 3,449 tons; 1916, 5,388 tons. The customs statistics show that Swatow is one of the chief ports of export for this product. Most of the local shipments, says the United States Consul at Swatow, go to Hong-Kong, where the indigo is re-exported, largely to Chinese ports for use by native dyeing establishments. Siam and Singapore also receive some of the local product.

CONSERVATION OF AMERICAN RESOURCES.

The "Conservation Division" of the United States War Industries Board endeavours to prune from industries what is described as "the excrescences of peace-time trading, and to secure the concurrence of the industries themselves in the manipulation of the war-time knife."

In the wool trade the manufacturers are now producing only staple fabrics, and are mixing substitutes with the pure wool. They have also cut down the sizes of samples. The makers of men's and boys' clothing have reduced the number of their models, eliminated all features that use up cloth unnecessarily, and reduced the sizes of samples. In the trade for women's clothes the makers have cut down the number of models, and are confining themselves to those which are most economical in material.

As with woollen clothes, so with boots and shoes. The number of styles has been greatly reduced, fancy colours have been got rid of, and the height of boots has been restricted. Steps are being taken to standardise trunks and travelling bags made from leather.

Plans are being developed for standardisation in all branches of the hardware industry. Types of stoves and furnaces which used an excessive amount of iron and steel in their construction have been eliminated, and the models have been generally reduced in size and type by 75 per cent. In a similar way three-quarters of the types of ploughs and other agricultural implements have been got rid of. It is estimated that a saving of at least 30 per cent. will be made in the consumption of tin. Substitutes for tin are being employed wherever possible by manufacturers of solder, babbitt metal, white metal, bronze castings and ingots, tinfoil, silver-plated hollow ware, and so on.

A remarkable reduction has been effected in the number of sizes and types of pneumatic tyres for cars. Tyres have been standardised, the pneumatic varieties, numbering 287, have already been reduced to 32, and a further reduction to 9 is promised in two years from the present. In other branches of the rubber industry plans are being worked out to achieve similar results.

The general idea of conservation is being developed throughout all those miscellaneous trades in which civil consumption is larger than is really necessary. Thus the range of colours in paint and in grades of varnish has been materially lessened and sizes of cans reduced in number. Half-gallon cans and those smaller than half a pint have been abolished. The manufacturers of pencils, corsets, caskets, enamel ware, beds, and numerous other articles of individual consumption are working out with the division plans for eliminating superfluous varieties and standardising those which remain. The utilisation of waste material and the provision of substitutes for sulphuric acid, chlorine, and caustic soda are under consideration.

Large economies in space and in material for packing goods are under way, and dry goods wholesalers are reducing the number of trunks carried by their travelling salesmen in order to lessen the amount of baggage handled by the railroads. In many of the cities of the United States merchants have restricted deliveries to one a day over each route, have stopped special deliveries, and have curtailed the privilege of returning goods sent on approval. In some of the smaller towns

co-operative delivery systems have been started. By employing the above measures merchants are able to carry on their delivery services with from 35 to 60 per cent. fewer employees.

GENERAL NOTES.

Developing the Kelp-product Industry.—Kelp as a source of acetone is something new in the chemical industry, and, according to *Chemical and Metallurgical Engineering*, chemists all over the world are watching with deep interest the development of the enterprise of the Hercules Powder Company near San Diego in California. Since the works were started in 1915, this plant has rapidly increased the number and range of its products, putting on the market some new materials full of industrial promise. On these products the commercial success of the acetone manufacture will largely depend. Expressed in its simplest terms, the basic principle of the process of kelp reduction lies in the destruction of the cellular tissues of the leaf by fermentation. This brings the potash into solution and forms acetic acid. The acid is neutralised with limestone, giving calcium acetate, potash, and iodides in the solution. This wet fermentation method has been developed with marked success by the Hercules Powder Company. The products now obtained comprise, besides acetone, potassium chloride iodine, ethyl acetate, propionate and butyrate in commercial quantities. But the process requires an expensive plant. The dry distillation process now being developed by the United States Department of Agriculture in their experimental plant at Summerland, California, and in the Forest Production Laboratory at Madison, Wisconsin, may prove more economical in first cost than the other. Potassium chloride, iodine, charcoal and distillates will be the chief products. Probably commercial success in the future will depend in large measure on the uses found for the two latter products.

Ship Repairs.—The Directorate of Ship Repairs began operation in June, 1917. More than 10,000 ships have been dealt with by the Department, repaired, and returned to service, between June, 1917, and October, 1918, apart altogether from vessels of the Allies and neutrals, which have been dealt with, and apart also from a vast number of small craft not included in these figures. At least half a million tons of French shipping has been repaired and returned to service this year alone, while during the last four months only more than 1,000,000 gross tons of Allied and neutral shipping has been repaired. The fitting of troopships, transports, hospital ships, etc., both for the British service and the American, has been a task of great magnitude, while the foreign section has established branches in all parts of the world.

Paris-Dieppe Canal.—A project is on foot for the construction of a canal communicating directly between Paris and the sea at Dieppe. The idea was first started by Vauban, in 1694, and has often been revived. It is regarded at present as important, in view of after-war developments. The Seine does not suffice to deal with the traffic, and there have been as many as seventy ships in the estuary awaiting their turn to enter Rouen, besides 1,300 barges awaiting their turn to leave. The canal is designed to accommodate the largest boats at present traversing the French waterways, which carry 1,400 tons, with a draught, when loaded, of 3 m. The barges, according to the *Engineer*, are to be hauled by electric locomotives running on a track alongside the canal, or on a roadway. The canal would be 165 kilometres in length, as compared with 350 kilometres, the length of the route by the winding Seine from Paris to Havre.

Canadian Paper.—Since the outbreak of war, according to the *Engineer*, Canada has been able to export a very much greater quantity of paper and paper pulp than ever before. The value of the export of paper in 1912 was £300,000; in 1914 it had risen to £2,500,000; and in 1917 to £5,200,000. Similarly, figures for mechanical pulp in the same years were £700,000, £900,000 and £1,200,000 respectively, while those for chemical pulp rose from £600,000 to £2,800,000. Part of the increased values is due, no doubt, to enhanced prices, but the increase in quantity has been very great.

MEETINGS FOR THE ENSUING WEEK.

Monday, November 25...Cold Storage and Ice Association, at the Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. Sir Alfred Ewing, "Research in Refrigeration."

Geographical Society, Burlington-gardens, W., 8 p.m. Mr. Arnold Hodson, "Southern Abyssinia."

East India Association, in the Lincolnshire Room, 7, Tothill-street, Westminster, S.W., 3.15 p.m. Mr. S. S. Thorburn, "India: a Democracy."

Tuesday, November 26...Colonial Institute, Central Hall, Westminster, S.W., 4 p.m.

Wednesday, November 27...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. Lord d'Abernon, "Rival Theories of the Causes of Drunkenness."

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, E.C., 4.30 p.m. Mr. E. J. P. Benn, "Labour and Industrial Development."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Alderman C. Spencer, "National Kitchens and the National Health."

Thursday, November 28...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. Bhupendranath Basu, "Some Aspects of Hindu Life."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Mr. N. Bishop Harman, "Sight Saving Schools."

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—November 22, 1918.

No. 3445. NOVEMBER 29, 1918. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,445. VOL. LXVII.

FRIDAY, NOVEMBER 29, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 2nd, at 5 p.m. (Cantor Lecture.) JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." (Lecture I.)

WEDNESDAY, DECEMBER 4th, at 4.30 p.m. (Ordinary Meeting.) BENJAMIN SEEBOHM ROWNTREE, "Housing after the War." LORD HENRY CAVENDISH BENTINCK, M.P., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

INDIAN SECTION.

Thursday afternoon, November 28th; The Most Hon. the MARQUIS OF CREWE, K.G., in the chair. A paper on "Some Aspects of Hindu Life," was read by BHUPENDRANATH BASU, Member of the Council of India.

The paper and discussion will be published in a subsequent number of the *Journal.*

"OWEN JONES" PRIZES.

The Council are now prepared to offer six Prizes in each of the years 1919, 1920, and 1921 for the following subjects:—

In 1919.

ARCHITECTURAL DECORATION.—Including Stained Glass, Mosaic for Walls and Floors, Plasterwork in relief and incised, Inlaid Marble and Stones, Lettering for Memorials.

WOODWORK AND CABINET WORK.—Including Carving in Wood, Ivory and Bone, Inlay, Chairs, Chests, Cabinets.

TEXTILES (*a*).—Including Tapestries, Carpets and Rugs, Moquettes, Floor-coverings (*e.g.* Linoleums and Floor-cloths).

In 1920.

DOMESTIC POTTERY AND TABLE GLASS.

METALWORK.—Including work in Precious Metals, Ironwork, Jewellery, Enamelling, etc.

TEXTILES (*b*).—Including Lace,* Embroideries,* Openwork,* Dress Brocades, Dress Designs and Costume Accessories (including Fans), Printed Fabrics for Dress.

In 1921.

BOOK PRODUCTION AND ORNAMENTAL LEATHER-WORK.—Including Covers and Lining Papers for Bookbinding, Title Pages, Lettering and Printing, Posters, Trade Labels and Advertisements.

WALLPAPERS, and other Mural Decorations.

TEXTILES (*c*).—Including Damasks,* Brocades for Decoration and Furniture, Printed Fabrics for Hangings, Vestments and Church Fabrics (including Altar Frontals, etc.), Figured Velvets, and Figured Muslins.

Each Prize will consist of a bound copy of "The Leading Principles in Composition of Ornament of Every Period," from the "Grammar of Ornament," by Owen Jones, and the Society's Bronze Medal.

The competition is limited to students of Schools of Art. No competitor may send in more than a single design for each of the above-named manufactures, but that design may be accompanied by one or two working drawings or other illustrative sketches.

A sample of manufacture executed from the design may be submitted with or in substitution for the original design; but every submitted work must be approved by the master or other authority of the student's school, who must also certify that the design is the work of the student sending it in, and that it has been executed since the last competition in which the subject of the design was prescribed.

No candidate who has already received an Owen Jones Prize for any of the above-named manufactures can take part in the competition.

Competing designs for 1919 must be sent, carriage paid, and labelled "Owen Jones Prize Competition" on the outside, to—

THE DIRECTOR AND SECRETARY,
Victoria and Albert Museum,
South Kensington, S.W. (7)

* Designs for Bed-spreads, Table Covers, Cushion Squares and Tea Cosies will be eligible.

between June 23rd and June 28th, 1919. They may be delivered by hand on any one of the three days ending June 28th.

The sender must also notify the Secretary of the Royal Society of Arts by post that the design has been sent in, and must enclose stamps or P.O.O. for the return carriage.

No special conditions are laid down as to the size or character of the drawings sent in.

The awards will be made by the Council of the Royal Society of Arts on the recommendation of judges appointed by them.

The Council reserve the right of withholding any or all of the Prizes offered, and they will be the sole judges in each individual case of the qualifications of a competitor to receive an award.

All possible care will be taken of the designs, but the Council accept no responsibility for injury or loss.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

Wednesday, November 27th, 1918; Sir Thomas Barlow, Bt., K.C.V.O., M.D., F.R.C.P., F.R.S., Past-President of the Royal College of Physicians, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Coleman, George, London.
Kindersley, Sir Robert Molesworth, K.B.E., Abbots Langley, Herts.
Lechertier, Jules Eugene, London.
Little, G. W., Manchester.
Paisley, John, Glasgow.
Peacock, E. R., London.
Stone, Edward William, Surbiton, Surrey.
Trotter, Miss Jacqueline Theodora, London.

The Chairman, in introducing Lord D'Abernon, said they would all agree that, amongst the trials that had surrounded them during this terrible war, it was an infinite satisfaction that the great drink question had been, if not completely dealt with, at all events considerably mitigated, and every true patriot must be grateful to Lord D'Abernon and the Liquor Control Board for the work they had done in this connection. It was obvious that thoughtful men who had been engaged, not theoretically only, but practically with the problems of the drink question during these months and years, must have made many important reflections and indeed almost mathematical deductions on this vital matter. After the work that had been done it would be a burning shame and an everlasting disgrace if we were to allow the drink question to get back into its pre-war stage. Whatever happened, they would all agree about that, and he was quite certain that Lord D'Abernon's important paper would help to clarify their views and inform their minds as to the line along which further improvement was to go.

The paper read was—

RIVAL THEORIES OF THE CAUSES OF DRUNKENNESS.

By Lord D'Abernon, G.C.M.G.

My original intention in the present paper was to elucidate the problem of drink control by a critical examination of the various methods which have been tried or advocated in this and other countries with a view to its solution. On closer examination, however, of the facts and figures available relating to other countries, I found that the statistical data were so scanty and so partial that they did not form the basis of a detailed comparison. Our own position in this matter of statistics of alcohol is nothing to boast of, but it would seem that we are somewhat in the position of the one-eyed kings of a blind world.

I have therefore modified my original design, and shall invite your attention to a somewhat different aspect of the problem, to a subject of great theoretical and practical interest—namely, the fundamental causes of inebriety.

In dealing with the question from this point of view, it will be desirable to start from the root of the matter, and to recall this primary and essential consideration, that the reason why there is a drink problem at all is simply because the use of alcoholic beverages, when carried to excess, has results which endanger public order and injure the health and efficiency of the community. The problem depends, that is to say, not on the use but on the abuse of alcohol; and therefore the first step in our inquiry must be to ascertain the cause or causes of this abuse, to explain the fact that, while some people in the use of alcoholic beverages keep within the bounds of moderation, others drink to excess. Now this fact may be explained in two ways: either it may be assumed that excessive drinking is mainly due to bad general environment, such as bad housing, insufficient amenities for food and refreshment in works, the absence of healthy recreation, and more specifically to the bad conditions under which the liquor trade is carried on, to unregulated access to too strong alcohol, to an excessive number of public houses, to the encouragement of intemperance by force of custom and public fashion, to undue solicitation and so forth; or, on the other hand, the view may be held that it is a question of the individual drinker, so that the people who drink to drunkenness, or to the injury of their own health and efficiency, and to the disturbance of public order, do so

more through perversity or morbid pre-disposition than on account of the undue facilities available.

Obviously these different views connote different conceptions of policy in regard to intemperance. Those who attribute excessive drinking to what we may call environmental influences, will seek the remedy in some form or other of liquor control, whether by regulation of the hours and conditions of sale, by reduction of the number of public-houses, by State or municipal management of the trade, or other such means. Those, on the contrary, who believe that drunkenness is wholly or mainly the fault of the drunkard, will turn for the solution of the problem (so far as its solution may be looked for from action by the State as distinguished from educational appeals or the teachings of religion and morality) to individual methods, to punishment by fines or imprisonment, or to treatment in inebriate reformatories. In the latter case, the method adopted is direct and is applied to the person; in the former case, it is mainly indirect and seeks to improve the condition of the person by improving his surroundings and thus influencing his habits and conduct.

In this country, prior to the war, the attitude of the State in regard to the liquor problem seems to have been inspired to some extent by a mixture of these two principles; but much more by the temperamental view than by the environmental; the licensing laws, in fact, represent a very timid and imperfect application of the principles of control, out-balanced by a much more vigorous and thorough application of the principles of individual repression. Hence, so far as the practical results of the system are of any use for our future guidance, it is chiefly, indeed, we may say exclusively, in regard to what they show concerning the methods of repression as applied to the person, and concerning the soundness of the theory implied in these methods—the theory that excessive drinking depends upon individual rather than on environmental causes. And looked at from that point of view, the results were discouraging. Thus, in England and Wales in the pre-war year 1913, there were no less than 188,877 convictions for drunkenness, 153,112 of men and 35,765 of women. These figures had steadily risen between 1909 and 1913.

On the assumption, then, that drunkenness is due to vice or disease in the drunkard, the problem of dealing with it directly by punitive or other individual methods was not solved. Indeed, the prospect of an effective solution of the problem was remote, unless the measures applied under this theory had been so faulty as to afford no true test. The choice before the nation was either to acquiesce in the persistence of the evil, or to have recourse to the drastic remedy of the absolute prohibition of all alcoholic beverages as the only logical and complete solution on temperamental lines. Into the merits of this latter policy and into a discussion of the results which have heen obtained by such partial trial as has been made of it in other countries, I do not propose to enter at present.

We have now to discuss the opposed view—the view that intemperance is due in the main to what, broadly speaking, we may call environmental conditions, and that it can accordingly be removed or abated by improvement of the environment, notably by methods of regulation, control, and counter-attraction.

Now here we are obviously dealing with much more complex questions than are involved in carrying out the mainly personal and repressive policy which we have just considered. And we may, therefore, expect to find greater diversity in practice and in results.

The pre-war system of licensing in this country had two merits, and two only. It did not allow the growth of an independent interest like that of the "bouilleurs de cru," who have so long hampered reform in France, and it prevented anything like the illicit distilling which, particularly in the Appalachian Mountains region, has caused so much disturbance to drink control in the United States. But these merits belong rather to the revenue and excise systems than to licensing proper.

Outside these two points, it is difficult to find anything to praise. Conditions before the war gave no cause for satisfaction either to the State or to the public. They brought the trade into violent odium with a large section of opinion. Meantime the large profits, which should have proceeded from a gigantic payment by the public, never reached the shareholders or proprietors, having been squandered in foolish competition and speculation, in extravagant methods of production and trading, and in the reckless waste of material.

The conditions of life and work among the retail section of the trade were terrible in the extreme. Their death-roll was comparable to that prevailing among the fever swamps of the tropics, so that no insurance office would accept them except at special rates. Their

hours of labour were longer than those of many sweated trades, and their duties, in dealing with frequent drunkenness on the one hand, and in evading police interference on the other, such that few undertook the task to whom other careers were open.

Regarded as an instrument of revenue, the system gave considerable, but quite inadequate, results. Confusion of mind regarding the precise relationship and legal status of the State and the Trade led the former to lose the advantage of many rights which inherently belonged to it; while the latter, claiming theoretically ordinary trading rights instead of the very peculiar and exclusive privileges which it in facts enjoys, lacked both the status and the authority which its position as a participant in, and administrative agent of, a virtual Government monopoly would probably have furnished, and which may possibly be necessary to the delicate, difficult and responsible duties entrusted to it.

In respect of the type of public-house created, the number permitted, and their distribution, the system was a complete failure.

It put a premium on the least admirable type of tavern, and mulcted the progressive trader who tried to make his house more than a mere drinking shop, or who sought to improve its hygienic conditions. And it failed entirely to give effect to what is probably the most important principle of liquor control—the regulation of the hours and circumstances of drinking on physiological lines.

The wide prevalence of alcoholism under this system was, therefore, nowise surprising, especially when it is borne in mind that the population catered for by these practically uncontrolled public-houses had hardly any, or at best, only moderate means of obtaining food or non-alcoholic refreshment outside their homes.

The failure of the pre-war licensing system in England cannot, then, be held to disprove the truth of the environmental theory of drunkenness; nor does it furnish any argument against the value of control.

Under it, environmental control was quite the minor factor, and, so far as applied, was applied without intelligence. And it would not have been an adequate test of the theory even if its more glaring deficiencies had been repaired by amendments, such as a reduction in the number of licensed houses, or the reformation of the existing type of public-house so as to convert it into something more fitted to be a centre of social life. These changes were and are most desirable. But if they were carried into effect to-morrow, we should still be very far from a complete and adequate system of control. And experience shows, in fact, that they could not provide anything approaching a solution of the drink problem. A redundancy of public-houses is undoubtedly a factor in the promotion of drunkenness, but it is a factor of secondary importance: there is only a limited correspondence between the frequency of drunkenness and a high ratio of public-houses to population. A reformation of public-houses, again, is desired by everyone, but it will not of itself remove the worse dangers of intemperance: the wide extension of the café system in Continental countries has not prevented a very serious development of alcoholism in wine shops and liquor bars—which exist contemporaneously with the café—though they are less seen by the passing tourist.

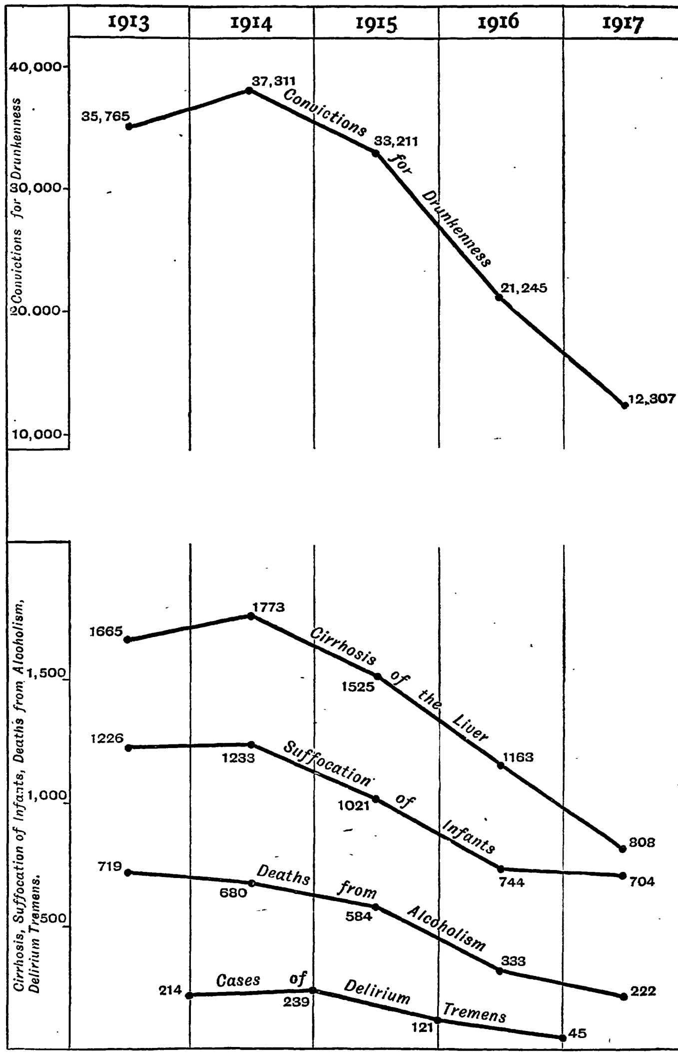
Neither can any argument against control be founded on the fact that there is still a drink problem—though a decidedly less formidable one than in the past—even under such systems of public ownership as the Gothenburg system or the Norwegian Samlag. State or municipal ownership undoubtedly facilitates the application of control, and under it control is probably more exact and more stringent; it may even in some places and at some time be an absolutely necessary condition for the effective enforcement of a thorough system of regulation. But in relation to intemperance it is, in itself, nothing more. That is to say, it is not an alternative to control, but a co-operative and perfecting agency, an aid to its enforcement, and the results obtained under the various forms of State management are mainly dependent, therefore, so far as the reduction of intemperance is concerned, on the adequacy or otherwise of the regulations established by the controlling authority. Where these regulations are very imperfect, or are inspired too much by purely fiscal considerations, or are unsound in principle, then—as, for instance, in the case of the Vodka monopoly in Russia, established in 1894, and maintained till the beginning of the war—the results are bad: it is generally admitted that under the monopoly drunkenness and alcoholic disease certainly did not decrease, and were probably more prevalent. Where, on the other hand, as under the Norwegian system, there has been a consistent policy tending to sub-

stitute beer-drinking, and especially the drinking of the lighter beers, for spirit drinking, a considerable reduction of alcoholism has been effected and the general result is good.

The question, however, still remains, whether the reduction of alcoholism that can be brought about by control is sufficiently large to justify us in concluding that the environmental theory holds true to such an extent that we may regard it, not as an interesting theory, but as a valid basis for action. This is a question that can only be answered by statistics, and the statistics which I propose to use for our discussion are those relating to recent experiences of liquor control in England and Wales. They have the advantage of being fuller and more exact than other available statistics of alcoholism, and, as they refer to conditions in our own country, their meaning and the deductions to be made from their face value are more easily understood. Further, the system of control, of which they express the efforts, is of a more comprehensive character than has been tried elsewhere, especially in regard to its definite conformity to the indications of physiological science. For these reasons we may consider that the results obtained here within the last three years should afford a better test than has been hitherto obtainable of the value of control, and of the extent to which the environmental theory covers the facts of alcoholism.

In putting before you the statistical evidence of these results, I shall confine myself to figures relating to intemperance in women. I do this not only because the statistics of men are obviously influenced by the absence in the Army of large numbers of the adult male population—though possibly not so deeply as appears to superficial observers—but also because it has been held that inebriety in women is peculiarly intractable; and the persistent recidivism of the female drunkard is, in fact, one of the stock arguments in support of the temperamental theory.

If the temperamental theory, therefore, is disproved on this basis, it will have been disproved in the arena most favourable to it.



STATISTICS RELATING TO ALCOHOLISM IN WOMEN IN THE YEARS 1913-1917 (England and Wales).

Year.	Convictions for Drunkenness.*	Deaths from Alcoholism, excluding Cirrhosis of the Liver.*	Deaths from Cirrhosis of the Liver.*	Deaths from Suffocation in Infancy.
1913	35,765	719	1,665	1,226
1914	37,311	680	1,773	1,233
1915	33,211	584	1,525	1,021
1916	21,245	333	1,163	744
1917	12,307	222	808	704

*Cases of Delirium Tremens treated in certain Poor Law Infirmaries.**

Period.	Number of Cases.
Pre-war, 1913–14	214
Pre-control, 1914–15	239
First year of control, 1915–16 . .	121
Second year of control, 1916–17 .	45

* Women only.

The table to which I have now to draw your attention shows for England and Wales, during the years 1913–1917, the number of convictions of women for drunkenness, the number of women certified as dying of alcoholism and of cirrhosis of the liver, and the number of deaths from suffocation in infancy—this being notoriously in the large majority of cases a result of maternal intemperance. In the column below the table are shown, also for twelve-monthly periods, the number of women treated for delirium tremens in the English poor law infirmaries from which records of that disease have been obtainable. From these figures you will see that, concordant with appropriate regulation of the conditions of drinking, reinforced by such indirect influences as the provision of canteen facilities, drunkenness in women, as compared with the pre-war year 1913, has been reduced by 60·6 per cent., their mortality from alcoholism and from cirrhosis of the liver has decreased by 69·1 per cent. and 51·5 per cent. respectively; the frequency of delirium tremens in women has fallen by 79 per cent., and the deaths from suffocation in infancy by 42·6 per cent.

I would direct your attention particularly to the large reduction in the prevalence of alcohol disease which these figures indicate, for the drinking that leads to delirium tremens, or to cirrhosis of the liver, is not the casual debauch of the occasionally intemperate, but the steadily continued excess of the confirmed drunkard—the type of alcoholic, that is to say, who should, *ex-hypothesi*, represent in the highest degree the force of the temperamental factor. And in this connection I may add that an even greater falling off has been brought about, within the same period, in what, in the official categories, would rank, no doubt, as the most extreme and difficult class of drunkards—namely, the drunkards amenable to the Inebriates Acts. Thus the number of persons proceeded against for habitual drunkenness in England and Wales, which in 1913 amounted to 332, was only 27 in 1917, while the admissions to inebriate reformatories similarly declined from 310 to 29—a result, however, to which other factors may have contributed.

From the concordant evidence of all these statistical data, is it possible to draw any other conclusion than this, that in the causation of intemperance, the environmental factor, though not, of course, exclusive, is certainly dominant, and even so dominant as to warrant the hope that methods directed to it will go a long way towards the solution of the social problem of alcoholism?

Now this conclusion, if sound, would be one of most hopeful augury. It would justify us in looking forward to the practical abolition of drunkenness as it used to exist here, and this without any need of increased severity towards the individual offender. It would support the view that men and women mainly fall into drunkenness in the absence of reasonable facilities for avoiding it and reasonable guidance as to how it can be avoided. If these facilities and that guidance have been largely lacking in the past, the fault is in a great measure to be imputed to the mistaken way in which the drink question has been commonly regarded. It has been viewed in the light of preconceived theories, and its solution has been sought through purely empirical methods, devised in the absence of knowledge of the essential facts—on which, indeed, few reliable data existed—and without impartial study of the underlying and governing conditions. There is no apparent reason why the future should not show us a better way; why it should not give us not only the knowledge that we lacked, but the courage and the wisdom to apply that knowledge, provided that we can get clear of old prejudices and old catchwords.

The most vital and interesting claim for the work of the last three years is, not that it effectually prevented alcoholic excess from interfering with national efficiency in the prosecution of the war—that, I hope, is common ground—but that by practical experiment and trial it has thrown so much new light on the problem that the whole position has to be considered anew. Reform can now be entered upon with a firmer hope and a more confident assurance. New and easier avenues of approach have been discovered, larger vistas of attainment to conditions far above previous contemplation are now open.

Those of you who have long and earnestly striven in the cause of improvement may now, without undue optimism, assert that a

permanent solution on lines of general consent is more nearly within reach than at any previous period, without the sacrifice of any reasonable objective and without injustice or injury to any legitimate interest.

COMPARATIVE MORTALITY FIGURES FOR (a) ALL CAUSES, (b) ALCOHOLISM AND LIVER DISEASE, AND (c) PHTHISIS OF MALES AGED 25–65, IN GENERAL POPULATION AND IN LIQUOR TRADE.

	All Causes.		Alcoholism and Liver Disease.		Phthisis.	
	1900-02.	1910-12.	1900-02.	1910-12.	1900-02.	1910-12.
All males	1,004 (100)	790 (100)	43 (100)	24 (100)	187 (100)	141 (100)
Innkeepers, publicans, etc.	1,781 (177·4)	1,265 (160·1)	312 (725·6)	183 (762·5)	271 (144·9)	196 (139·0)
Inn and hotel servants	1,883 (187·5)	1,205 (152·5)	180 (418·9)	75 (312·5)	543 (290·4)	305 (216·3)
Innkeepers, publicans, etc. (London)	1,562 (155·6)	1,204 (152·5)	300 (697·7)	159 (662·5)	247 (132·1)	206 (146·1)
Inn and hotel servants (London)	2,121 (211·6)	1,330 (168·3)	213 (495·3)	68 (283·3)	669 (357·8)	333 (246·2)

DISCUSSION.

THE ARCHBISHOP OF CANTERBURY said that he was glad to be allowed the opportunity of saying a few words. He thought that the occasion was an important one, because he had felt for a long time how desirable it was that the question should, wherever possible, be removed from the arena of what were called temperance circles—admirably conducted though they might be—into the circle of thoughtful people who viewed it as part of a larger issue. It had suffered in the past from its isolation from the other questions which bore upon it. He attached, therefore, special value to the opportunity of hearing Lord D'Abernon. The country was fortunate in having Lord D'Abernon to guide and preside over that exceedingly important Control Board which had done so much in so many different ways. He had brought to the subject the very kind of qualifications they wanted, both of high personal fitness and experience in statistical, financial, and administrative matters, and also of a tone of mind which everybody could trust as being free from the sort of bias which, rightly or wrongly, was commonly supposed to belong to those on either side who were dealing prominently and ordinarily with this question. The work of that Control Board had a value for the country not only in its direct, but in its indirect results. It had been constantly the case that upon this question people had theorised as to what would happen if one were able to enact this or that or the other, and to do it on a large scale over a considerable area as an experiment. But hitherto this had been impossible. There had been no power to bring about such an experiment on a large scale. In the war emergency, however, the country said: "Let us, at all events, try what can be done by making the great experiment of giving the Board enormous powers." Few people realised how enormous those powers were. The experiment was taken in hand by an exceedingly sane and competent body; it did not take any violent or extreme form, but the Board was able by virtue of the powers given to it to bring into operation experimental work over a large area which otherwise would have been impracticable. And it was exceedingly encouraging to those who desired to see different experiments made in the social organism to find how valuable were the results of that great experiment, carried on as it was under Government authority over a wide area. It had been shown to be possible to effect what had seemed like impossible changes, and, moreover, to effect them with the general concurrence of the community and with no real desire on the community's part to reverse them after the experiment had been tried. That was valuable as a piece of social reform, and as an example of what was practicable in the common life. The value of the work done by the Board had been enormously enhanced by the fact that a book had been published by Mr. Henry Carter on the Board's work—a book which, with great freshness and power of illustration, had set before everybody what the Board had done. Coming to the consideration of the paper of that afternoon, His Grace said that Lord D'Abernon, in bringing forward statistics, had rightly warned them against expecting the application of statistics of that kind to hold good in normal conditions of national life. He hoped that it would not be thought depressing if he said that he had a slight distrust of all the statistics given at this time, because, although the statistics to which Lord D'Abernon referred applied not to men but to women, yet the women in this country were under abnormal conditions. He was not at all sure that that did not make it better as regarded the result. The conditions might well have been of such a nature as to make the recorded improvement even more remarkable, but, nevertheless, they must be just a little on their guard against relying upon the statistics respecting women as being in themselves conclusive

with regard to the normal life of the country as a whole. He was entirely in accord with the general conclusion of Lord D'Abernon's paper, and with what was obviously the deduction in the minds of those who had worked on the Control Board, namely, that to deal with environmental conditions rather than to deal with temperamental conditions was the road along which they ought to go for getting their reform—their change for the better—in common life brought about. But if the environmental conditions were to be changed the public must "play up." They must help them to carry the thing through in the right way. There must be thought and resourcefulness and effort systematically and steadily carried on with a backing of public opinion in the locality, and votes must be given accordingly. It would not do to sit down and let things take their course. "England is a garden," wrote Rudyard Kipling, "but

Such gardens are not made
By saying, 'It is beautiful,'
And sitting in the shade."

There were other things to do. They must see that what was done was made general to the last possible degree, and the thing must not be left to what were called temperance efforts and temperance reform. He (the speaker) was the last person to decry these latter. Indeed, in a day or two a letter would appear in the press signed by himself, Cardinal Bourne, the Chairman of the Free Church Council, and General Booth, who worked together as presidents of the Joint Temperance Board of the churches, appealing to the country to see to it that the restrictions in force under the workings of the Control Board should not be relaxed, either during the period of demobilisation, or for a very long time after it. He believed it would be found that there was practically no opposition worth considering—though doubtless there would be opposition of a sort—to a continuance of the greater part or all of the restrictions. If so, that was an extremely important thing to remember. But it must be remembered by practically supporting the proposal at every opportunity and by voting for it next month. He was one of those who had not the opportunity of exercising the suffrage—criminals, lunatics, bishops, and peers being excluded from the franchise—but undoubtedly the matter should weigh at a Parliamentary election. The whole gist of present-day thought on the subject was in such a direction that they might expect to see big results come about by improving the environment, changing the conditions, rather than by tackling the individual, though this latter should never be forgotten. There had been times in history when, not by direct attack, but by changing environmental conditions, great wrongs were set right. Finally, he did not know whether he was permitted in this discussion to refer to any comparison which might, justifiably or unjustifiably, be drawn between ourselves and the United States and Canada. In the latter countries there had been considerable action which it would not be fair to describe as environmental, but which was temperamental also, and which dealt with the individual in the most coercive manner. It might be that such action was not applicable at present to England and English life, for new countries could do things that old countries might hesitate to do; but what the United States and Canada had done furnished a huge object-lesson which they could not afford to neglect. He would like to know what degree of public sanction would be necessary in order to have such action, locally or centrally, here, and if it were impossible to have such action in England, why it was impossible. It was at all events a thing which one day would have to be thought out. He was perfectly persuaded that it was in this direction that their work would best go forward, and the object-lesson which the working of the Board had afforded had been of incalculable value in this connection. Hitherto the choice of the legislator, as Mr. Carter had said in the book already referred to, had been between inaction and reform; now it would no longer be between inaction and reform, but between reform and a reversion to something less worthy.

MR. CECIL LUBBOCK said that Lord D'Abernon would understand that he, as a brewer, had watched the action of the Control Board during the last three or four years with extreme interest. The Control Board, acting as a public body in dealing with this matter, had really introduced a new note into the whole discussion. They had introduced a positive note, and had not stuck merely to the old negative attitude. Lord D'Abernon had started with the idea that alcoholic beverages were things which did exist, and that the public-house was an institution which was there and was accepted by a large body of the population, but he had also gone on to say that these things as they were at present were not what they ought to be. Up to the present time the subject had been wrongly treated by practical temperance reformers. They had supposed that the public-house must exist, and that alcoholic beverages were to be used, but they had said: "We will do our best to keep the public-house as disreputable as we possibly can." There was an old saying to the effect that the best public-house was the worst public-house. He assured them that that was the impression they had always received, and each reform had invariably been on the line of repression. The Control Board, on the other hand, had inaugurated public-houses of their own, and he had no doubt had greatly improved them. The ultimate result of their efforts had been, not a public-house gradually dying through stages of progressive disreputableness, but gradually rising to take its place in the community as a decent institution. It was the large respectable public whom they (the Trade) wanted to get into the public-house. By working in the direction of Lord D'Abernon's ideas, ultimately they would get to this position, that

a man could go into the public-house without reproach. Up to now the idea had always been that the public-house must be made and kept a place where a man could not go without reproach. The Archbishop of Canterbury's remarks that afternoon were all in the direction of total prohibition ultimately. [The Archbishop of Canterbury: I did not mean to say so.] That was the impression which he had received from what His Grace had said. He quite understood, although he did not share, the position of people who considered that any consumption of alcoholic beverages was wrong, and that the sale of liquor must be put down altogether. But he did hope that the new consideration which, Lord D'Abernon said, was to be brought into this subject, and the most interesting changes which had been made would render it possible that those who tackled the question from a different point of view, like the temperance societies and the various movements which the Archbishop of Canterbury represented, might come to see if something positive could not be brought about. The Trade had been conscious that they had been regarded as a kind of outcast, and kept at arm's length as much as possible—and if you treated a man as an outcast it was a sure way of making him one. Such an attitude did not make it easy to improve the conditions of the trade. The line which Lord D'Abernon had indicated was the one on which he hoped the discussion would proceed, and he was really grateful to the Control Board for having brought that new idea into the system, and he hoped it would continue.

Major Sir Robert Armstrong-Jones, R.A.M.C., M.D., said that he appreciated greatly the very sane criticism of the Archbishop of Canterbury. He did not agree with what His Grace had said as to the value of statistics. The arithmetical argument was one that appealed to most people. With regard to the speaker's own special line, that of mental diseases, it had been the idea of the Lunacy Commissioners that if alcohol were abolished the solution of the question of insanity would be found. They did not say that drink was the only curse, but they did say that it was the short cut to all the curses. There was a certain disease—a communicable disease—which was an absolute and positive danger to the country, and in combating which no one had rendered greater service than their Chairman of that afternoon (Sir Thomas Barlow), and to that disease alcohol was a short cut. They had had that day a most overwhelmingly convincing argument that the right end of the stick had been seized during the last three years, and he considered that Lord D'Abernon was the greatest sanitary reformer since Moses! His was a paper which should not be discussed but should be accepted *ex cathedrâ*. With regard both to men and women there had been a diminution in insanity and a diminution also of drunkenness. Those who, like himself, had served on Petty Sessions were well aware of the difference in the number of cases coming before them now and the number which came before the war. It was well to note that what Lord D'Abernon had done had been done at the request of the authorities—munition, transport, military, and naval. The Board had considered their request and had given reasonable heed to the reasonable claims of men and women. This action covered 38 millions out of the forty millions of the population of this country. He hoped that this was the beginning of a new era. It would be more than a crime to go back to the pre-war conditions. He was grateful to Lord D'Abernon for a philosophical paper. Philosophy was the thing which unified all knowledge. He would like to have seen one further point introduced, namely, as to what it was which made men drink. The reason was that drink made glad the heart of man. That gladness of the heart of man was a misconception. The poor people drank because they mistook the feeling of stimulation after drink for a feeling of nourishment—a feeling like that after dining on a chop or a steak. That was the reason why the poor drank, and they ought to be educated, and—a point on which Victor Horsley, of blessed memory, was extremely insistent—you could only educate them when you began with the school. There was a difference between the reason for drinking among the poor and for drinking among the rich. The rich drank for æsthetic purposes. It was nice to see the cut glass on the table and to have things rich and mellow and transparent. They drank, really, in order to make a good meal a better meal. The speaker thought that the Archbishop might have laid a little more stress on the power we had of educating the young people.

Mr. H. Charrington thanked the Chairman for asking him to make a few remarks. He had had the honour—and he deemed it an honour notwithstanding all the degradation showered on the Trade — of being connected with his brewery for thirty years. The Chairman had asked him a question with regard to the present brew. His experience, which extended over a considerable portion of England, was that the working-classes, speaking broadly and generally, did not like what they called this Government "coloured water." It was what they used to call "swipes" at school. To speak broadly, there was grave dissatisfaction, not only among the agricultural labourers but among miners and munition workers and others engaged in manual toil. When Lord D'Abernon spoke about England and Wales, perhaps it was not known to some of the audience that there were certain parts of England at the present moment where the action of the Control Board had not come into force, and he would like to know whether those counties or portions of counties where the Control Board was not in force were included in the statistics given. Another point on which he would like to ask a question

was this: he understood Lord D'Abernon to say that the figures as regards England and Wales only were shown because those for Scotland and Ireland were not available. Those figures for Scotland and Ireland might, perhaps, not show such good results as those for England and Wales, and he wished to know if any indication as to their tendency could be given. As to women inebriates, he did not think that such women should be allowed to bear children. They had got to think of the future of the race. If a woman suffered from alcoholism she could not be the proper type of woman for motherhood. On the general question he said that they had always had their trade maligned in every possible way, but the public never realised when the fanatics got up and talked about drunkenness and the totals of convictions that probably the same individual was being convicted over and over again. They all remembered Jane Cakebread, who had three or four hundred convictions against her. In his opinion that woman ought to have been in a lunatic asylum. [Sir Robert Armstrong-Jones: She was, and died in one.] Mr. Charrington, continuing, said that the confirmed inebriates falsified the statistics, or at least made the deductions misleading. They caused the teetotal fanatic to point the finger of rebuke, whereas the actual number of individuals affected was much less than the number of convictions. He disagreed with Sir Robert Armstrong-Jones's remarks as to why the rich man drank. The rich man drank because he appreciated the quality of the fine old vintages which many of them had not only been brought up on, but, happily, were drinking now. He added that when the alterations as regarded gravity were brought into force, Ireland was treated on quite a different basis from England; but if Ireland was allowed to have beer of a certain strength, then certainly, if he had his way, he would stick to the standard gravity to which they had all along been accustomed. His own firm was one of a few firms which so long as they had the option of keeping out the Government low-class beer did so, and their customers were not ungrateful.

Sir Alfred Pearce Gould, K.C.V.O., said that he was under the disadvantage of not having heard the paper, but he gathered that it had dealt largely with the results of the action—the laudable action—of the Control Board. There was one point to be remembered about these restrictions. This was that they were supported and assisted by another action which ought also to receive some credit for the result, namely, the great reduction in the amount of alcoholic beverages that the public could possibly get. He approved to the full of the restriction of hours and other reforms—not one word did he say against them—but they must recognise that alcoholic drink was the cause of drunkenness, and anyone familiar with the history of this question knew that the amount of drink consumed was an exact guide to the amount of drunkenness in the country. The improved conditions of sobriety in this and other cities, while in part due to the restricted hours, were, he believed, even more due to the less amount of alcoholic drinks that people could get. His second point was that he would be glad if Lord D'Abernon would enlighten them upon the way of applying the restrictions for which he was responsible to all classes of the community. The restrictions of the Board of Control had been splendid so far as they had gone, but they had not influenced the private drinker, the man in his own house with its well-stocked cellar, who had been able to drink at any time, night or day. If they were to control this habit, they must not be content with controlling the licensed houses—this was a bigger question than that. His third point was in response to the appeal made by Mr. Lubbock. He (the speaker) was a teetotaller, but he was there to say that this question was not to be solved only by the teetotallers; it was to be solved by all classes of the community, and they wanted the help of brewers and distillers. Great Britain would not be able to go on during the next ten years if drinking habits were kept up as before the war. With well on to a million of her young men dead, and vast numbers of others crippled, and the country impoverished in material resources, the outlook was very grave, and they all needed to join together in this movement. What did they want in this country? They wanted distillers, not to make drinkable gin but commercial spirit for the use of manufacturers and for motor transport. They wanted all that the distillers could give them, but put to a worthy use. He suggested that Mr. Charrington might perhaps be looking at this question with somewhat prejudiced eyes. Something had been said as to why poor men and why rich men drank, but alcohol was a narcotic. The poor man drank to get rid of the dull pressure of the life he had to live. Could they blame him, with his long hours, his uninteresting labour, and the kind of home to which too often he had to go? It was the one narcotic the Government allowed him to get. He drank to drown his sorrows, it was said. They wanted to lighten the load of the working-men and the working-women of this country. They wanted to ease the pressure on their life in some way. They wanted all the efforts of that great institution so worthily represented by His Grace of Canterbury to help in lightening the burdens of these people and so enable them to withstand temptation.

The Bishop of Llandaff expressed his deep gratitude to Lord D'Abernon for what he had told them, as well as for what he had done. The speaker was quite sure that the work of the Control Board had borne magnificent fruit in this country, and it would be a deplorable thing if the country should for a moment think of relaxing these con-

ditions to any great extent when the times of peace were upon them. Undoubtedly environment was one of the great things to consider, but they would not get a better environment unless they opened their eyes to see the absolute necessity of it. They must realise the urgent importance of providing better dwellings and better amusements for the people, and unless this were done they would never deal effectively with the question. A good deal had been said that day about drinking among women. Lord D'Abernon dwelt chiefly upon the improvement among women in this respect since the war began. There was one aspect of this question which had to be faced, namely, that one of the great causes of drinking among women was the enormous facilities which had been put into their hands through the existence of grocers' licences. He was quite aware that this was a difficult question to deal with. When first introduced by Mr. Gladstone, it was honestly regarded as a temperance measure; but the effect of the Act had been an enormous increase in drinking, especially among women. They had to face this question from a national standpoint. They had learned during the last four years to be willing to make sacrifices, and one's hope was that in the days of peace they would be able to act upon the lesson, and to show the same willingness for sacrifice when the prosperity of their country and the health of future generations were concerned.

Dr. C. W. Saleeby said that Lord D'Abernon had made a serious contribution to that old biological controversy as to the relation between heredity and environment, between Nature and nurture. He directly contradicted certain modern theories, eugenic and others. But the speaker supposed that there would always be a small proportion of the people who would do any silly thing which there was to do because other people were doing it, and therefore there would always be room for the existing Mental Deficiency Act and also for an amended Inebriates Act. The question of individual temperamental aptitude was interesting. There was, for example, the case of the Scots. Why did the Scot drink? It was maintained, in the first place, that the Scots drank because they had only recently had access to alcohol; in the second place, because of their climate; and, in the third place, because of their intensely sober, not to say glum, disposition. A remark of Dr. Johnson with regard to the Scot and whiskey would be recalled. On the practical issues of the question, he (the speaker) wished to point out that the Continental temperance reformer was not by any means so enthusiastic about the café system of the Continent as we were. It was thought to be better if a man had to stand up to drink, because in that case he would only drink for as long as he could remain standing. When he sat down it was a different proposition. Also there was the point that to make a place to which women and children were encouraged to go, tended to connive at racial poisoning through the mother. Those who kept and worked in public-houses were subject to a terribly high death-rate, and it was extremely important to learn from Lord D'Abernon that, owing to fewer hours of opening, the figures under this head had improved. Lord D'Abernon had referred to the influence arising from the tone of the people around one. When he (the speaker) was an undergraduate in Edinburgh many of his fellow-students were accustomed to get drunk purely through silliness and folly. And since most men went on being puerile until they became senile, it would be seen how that persisted. Lord D'Abernon had disproved the stupid and abominable lie which had been habitually used and believed, not merely by foolish people but by such an intellectual statesman as Mr. Balfour, that you could not make people sober by Act of Parliament. Mr. Balfour would not say that again. The fact was that you could make people either drunk or sober by a single Act of Parliament. Never again would that lie be repeated. It was a splendid thing to have this matter removed to the sphere of science and toxicology. His experience of many temperance meetings, which he had been attending and addressing now for a number of years, was that they were full of alleged humour, alleged religion —he used the word "alleged" because the religion so often appeared to be pharisaism—and alleged music; and what those things had got to do with a problem in social science and applied toxicology he could not for the life of him understand. Armistice week was Lord D'Abernon's greatest triumph—a wonderful tribute to the efficiency of his provisions, and the speaker could speak from experience, for he went among the crowds, into the music halls, and everywhere. The value of science as applied to the drink question was seen when one considered the position with regard to three great evils—tuberculosis, venereal disease, and alcoholism. The two former had made rapid strides against us in the past owing to the lack of scientific handling. In conclusion—and he had to speak hurriedly owing to the lateness of the hour—he would point out that they were dealing with a substance which was poisonous. It was a poison which had this particular characteristic, that there was a long interval between the minimum toxic and the minimum lethal dose, and surely the proper principle, if people *were* going to drink poison, was to dilute it.

Lord D'Abernon, in reply, said that everyone would agree that the discussion had been illuminating. To him it was particularly gratifying in the sense that they had heard authorised opinions from both sides. Nothing more helpful to the solution of this great problem could be conceived than the bringing of people with different views into the same room. He was particularly glad of Mr. Lubbock's contribution, which showed

a reasonable and intelligent attitude and a desire on the part of the Trade to co-operate in the removal of drunkenness. He earnestly hoped that the country could count upon the intelligent and progressive interest of the Trade in this question. Turning to the points made by the various speakers, the Archbishop had said that he was sceptical about all statistics, and that undoubtedly the conditions affecting women had been unusual and extraordinary. The speaker quite agreed, but he also agreed that, judging by past experience of war time, the extraordinary side had been in the direction of greater intemperance. So far as one could form an opinion, previous war periods had been distinguished by an increase of intemperance even in excess of the increase of liquor drunk, so that the conditions during the past three years would have been undoubtedly conducive to greater inebriety in the absence of governing and restraining factors. His Grace had also spoken of his interest in the experiment in total prohibition in Canada and the United States. He and those associated with him on the Board proposed to take steps to remain thoroughly well informed on the results of prohibition, either local or general. With regard to Mr. Lubbock's point, he would say this, that in his judgment the real interests of the Trade and of Temperance were not incompatible. He saw little necessary opposition between them. Mr. Charrington had asked a question about his figures; they applied to the whole country, scheduled and non-scheduled, save in respect to delirium tremens; here the figures were limited to certain districts, all scheduled, the other figures not being available. The figures for the non-scheduled areas were not very important, and there was this further fact about the non-scheduled areas, that not only was the population to begin with inconsiderable as compared with the scheduled areas, but as these non-scheduled areas were very largely agricultural and non-munition, their population had diminished during the war as that of industrial areas had increased by migration. The reason why Scotland was not included was because the figures did not exist. Such data as did exist were not really comparable. But the bearing of such data as were available was to show that in Scotland also there had been a reduction in drunkenness, not as large, though nearly as large, as in England. If in England drunkenness had come down from 100 to 20, in Scotland it had come down from 100 to perhaps 25 or 27. Sir A. P. Gould attributed a large effect to the reduced quantity of alcohol available. That was a very plausible view, and the speaker was not prepared to dissent from it categorically; but it had probably less importance than would be thought at first sight. The two curves of reduced drunkenness and reduced quantity of alcohol available were not parallel. They had diverged widely since control. The first reduction of quantity of any considerable amount took place in March, 1917. In the months that followed, the curve of reduced drunkenness, which one would have expected to see fall more rapidly, fell less rapidly than before. He attributed that in a great measure to the fact that the absence of sufficient liquor to last during permitted hours caused "rush drinking," and he thought that rush drinking probably led to increased inebriety. That was to be set off against the decrease of drunkenness due to the decrease of liquor. He would not be at all surprised if an increase up to a certain level of light beer was beneficial to the cause of sobriety, but this was debatable ground. The point he wanted them to carry away was that the curve showing the reduction in the amount of alcohol available for drinking, and the curve of reduced intemperance had not in the past three years coincided. The reasons were not certain and were open to friendly discussion. [Mr. Charrington here asked a question about Ireland.] Lord D'Abernon said that he had not got the figures available for Ireland. There had been a considerable diminution of drunkenness in Ireland, but not to such an extent as in England and Scotland. He would like to defer an answer to the question as to whether an Inebriates Act was still necessary On the present amount of drunkenness he did not think a new Inebriates Act was required; but possibly after the war there might be a recrudescence of inebriety, and some increase of stringency might be desirable or necessary. Certainly, the numbers whom it would affect at the present moment were hardly such as to justify legislation. His conclusion in favour of the environmental theory was not exclusive of the temperamental theory, but merely that the balance of evidence pointed in the direction of environment as being the most profitable and hopeful field for legislative and administrative action.

On the motion of the Chairman a vote of thanks was accorded to Lord D'Abernon and the meeting terminated.

OBITUARY.

Ichisuke Fujioka.—Information has been received of the death, on March 5th, of Mr. Ichisuke Fujioka, who was elected a Fellow of the Royal Society of Arts in 1915. He was born at Yamaguchi in 1857, and after graduating from the Tokyo Engineering College, he was appointed Assistant Professor and subsequently Professor there. He resigned his chair in 1886 to become Engineer to the Tokyo Electric Light Company. He travelled in Europe and America in order to study electric light undertakings in various countries. In 1891 he was appointed a Lecturer in the Imperial University of Tokyo, and after a further trip to Europe and America he became chief manager of the Tokyo Electric Light Company, and Advisor to the Enoshima Electric Railway Company.

GENERAL NOTES.

British Science and Invention Exhibition.—In view of the wide public interest taken in the British Scientific Products Exhibition, held at King's College, London, during the past summer, the British Science Guild has decided to organise another exhibition next year. The main object of the exhibition will be to stimulate national enterprise by a display of the year's progress in British science, invention and industry. Further particulars of the exhibition will be available in due course. A large part of the recent exhibition has been transferred to Manchester, where it will be on view at the Municipal College of Technology towards the end of next month.

The Indian Mints.—The mint in Calcutta is the largest in the world, says *Indian Industries and Power*, and the two Indian mints at Calcutta and Bombay claim to turn out more coin than all the other mints in the Empire. They have to satisfy the demands for coinage of every variety, not only of the 315 millions of India's inhabitants, but also of Egypt, Ceylon, British East Africa, Mesopotamia, Mauritius and the Straits Settlements. In the more primitive lands coins are necessary to a greater degree than in advanced countries where notes and cheques predominate, and this accounts for the enormous output of the Indian mints.

Tannin from Mangrove Barks.—The Australian Advisory Council of Science and Industry has appointed a special committee to investigate the tannin contents of the different mangroves available in Queensland, the extent and accessibility of suitable mangroves, the best methods of extracting the tannin, including methods of bleaching, the tannin qualities of extracts, and the costs and commercial prospects of the industry. Mangroves are very plentiful on the northern coast of Australia, and in Papua, and the bark of some species possesses a high tannin content; but it is apt to produce too red a colour, a disagreeable odour, and inferior leather, and is moreover liable to contain an excess of salt.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

December 4.—Benjamin Seebohm Rowntree, "Housing after the War." Lord Henry Cavendish Bentinck, M.P., will preside.

December 11.—Major-Gen. Sir Frederick Smith, K.C.M.G., C.B., F.R.C.V.S., "The Work of the British Army Veterinary Corps at the Fronts." The Duke of Portland, K.G., G.C.V.O., will preside.

Cantor Lectures.

Monday afternoons, at 5 p.m.:—

James C. Philip, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." Three Lectures.

Syllabus.

Lecture I. — December 2. — Principles of chemical equilibrium — Their application in technical gas reactions—Sulphuric acid contact process—Influence of pressure and temperature on yield—Synthetic ammonia—The water-gas equilibrium.

Lecture II.—December 9.—The *rôle* of the catalyst from the standpoint of physical chemistry —Catalysts in solution and in solid form—Catalysis in industry—Hardening of fats—Surface combustion—Oxidation of ammonia—Enzyme action —Acetaldehyde from acetylene.

Lecture III. — December 16. — Physical chemistry of the absorption of gases and dissolved substances—Solubility of gases in liquids as affected by pressure—Storage of acetylene—Charcoal as an absorbent of gases—Production of high vacua—Absorption of colouring matters from solution—Fuller's earth and charcoal—The dyeing process—Adsorption in soils.

Papers to be read after Christmas:—

Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. (Subject to be announced later.)

Sir Herbert Jackson, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

Frederick William Keeble, C.B.E., M.A., Sc.D., F.R.S. (Director of Horticulture, Food Production Department), "Food Production by Intensive Cultivation."

B. D. Porritt, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

A. F. Kendrick, Department of Textiles, Victoria and Albert Museum, "English Carpets."

H. Kelway-Bamber, M.V.O., "Railway Transport in the United Kingdom."

Lieut.-Colonel H. G. Lyons, D.Sc., F.R.S., "Meteorology during and after the War."

W. L. Hichens (Messrs. Cammel Laird & Co.), "The Wage Problem in Industry."

Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. Norman Williams, "The Hawaiian Islands and their Industries."

J. J. Crowley, D.Sc., "The Use of Electricity in Agriculture in Germany."

SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

PROFESSOR JOHN CUNNINGHAM MCLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

SANDFORD J. KILBY, "Indian Salt Manufacture."

H. KELWAY-BAMBER, M.V.O., "Coal and Mineral Traffic on the Indian Railways."

PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Exhaustion in India and its Influence on the Value of Crops."

THE RIGHT HON. LORD MONTAGU OF BEAULIEU, C.S.I., V.D. (Subject to be announced later.)

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

January 16, February 13, March 13, April 3, May 15.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

February 4, March 4, May 6.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m. :—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "Liquid Drops and Globules." Two Lectures.

January 1 and 8.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DECEMBER 2...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Cantor Lecture.) Professor J. C. Philip, "Physical Chemistry and its bearing on Chemical and Allied Industries." (Lecture I.)

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Dr. A. T. Schofield, "Christian Sanity."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. H. Kelway-Bamber, "Notes on Railway High Capacity Waggon Wheel Axes."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 7.30 p.m. 1. Dr. H. G. Colman and Mr. E. W. Yeoman, "Commercial 'Concentrated Ammonia Liquor' and its Impurities." 2. Mr. F. Butler Jones, "The Analysis of Commercial 'Pure' Benzols." 3. Messrs. J. J. Fox, E. W. Skelton, and F. R. Ennos, "The Analysis of Aluminium Alloys and Metallic Aluminium."

TUESDAY, DECEMBER 3...Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m. 1. Discussion on Mr. R. B. Joyner's paper, "The Tata Hydro-Electric Power-Supply Works, Bombay." 2. Mr. E. L. Leeming, "Road-Corrugation." 3. Mr. F. Wood, "Investigations in the Structure of Road-Surfaces." 4. Mr. T. B. Bower, "Notes on Road Construction and Maintenance."

WEDNESDAY, DECEMBER 4...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. B. S. Rowntree, "Housing after the War"

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.30 p.m. Mr. A. E. Berriman, "An Analysis of Test Records of some Petrol Engines."

Geological Society, Burlington House, W., 5.30 p.m.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 5 p.m. 1. Drs. E. K. Rideal and H. S. Taylor, "Recorder for Estimating Carbon Monoxide in Inflammable Gases." 2. Mr. A. D. Powell, "The Estimation of Phenacetin and other Para-aminophenol Derivatives by Hypochlorous Acid." 3. Messrs. H. E. Annett and H. Singh, "Effect of Morphine Concentration on the B. P. Method of Morphine Estimation."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor E. W. Hope, "The Rôle of the Ports in the Protection of the Health of the Nation."

THURSDAY, DECEMBER 5...London Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. C. B. Chancellor, "The Squares of London."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.45 p.m. Brigadier-General R. K. Bagnall Wild, "Shop Practice in respect to Aircraft Steels."

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Professor W. A. Haswell, "A Revision of the Exogonidæ." 2. Mr. C. D. Soar, "Exhibition of coloured drawings of British Mites." 3. The General Secretary, "The Tulbagh-Linné Correspondence."

Chemical Society, Burlington House, W., 8 p.m.

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, Westminster, S.W., 6 p.m. Professor Miles Walker, "The Supply of Single phase Power from Three-phase Systems."

FRIDAY, DECEMBER 6...Sociological Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m.

SATURDAY, DECEMBER 7...Chromatics, International College of, Caxton Hall, Westminster, S.W., 3 p.m. Dr. Dubash, "Colour Causerie."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—November 29, 1918.

No. 3446. DECEMBER 6, 1918. Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY

OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2)

Journal of the Royal Society of Arts.

No. 3,446. VOL. LXVII.

FRIDAY, DECEMBER 6, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 9th, at 5 p.m. (Cantor Lecture.) JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." (Lecture II.)

WEDNESDAY, DECEMBER 11th, at 4.30 p.m. (Ordinary Meeting.) MAJOR-GEN. SIR FREDERICK SMITH, K.C.M.G., C.B., F.R.C.V.S., "The Work of the British Army Veterinary Corps at the Fronts." The DUKE OF PORTLAND, K.G., G.C.V.O., will preside. (The paper will be illustrated with lantern and kinematograph views.)

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, December 2nd; PROFESSOR J. M. THOMSON, LL.D., F.R.S., in the chair. PROFESSOR JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., delivered the first lecture of his course on "Physical Chemistry and its Bearing on the Chemical and Allied Industries."

The lectures will be published in the *Journal* during the Christmas recess.

JUVENILE LECTURES.

The usual short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, January 1st and 8th, at 3 p.m., by Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, on "Liquid Drops and Globules."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

THIRD ORDINARY MEETING.

Wednesday afternoon, December 4th, 1918; STANLEY DAVENPORT ADSHEAD, M.A., F.R.I.B.A., Professor of Town Planning, University of London, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Allan, James McNeal, Sheffield.
Appleton, Thomas H., J.P., York.
Bailey, William Cooper, Harrogate.
Blee, Edward Lindsay, London.
Channing, Francis Chorley, London.
Ewen, A. J. Clifford, A.R.I.B.A., London.
Hamilton, James, Weybridge.
Hancock, A. J., Luton.
Henderson, John, Glasgow.
Kennedy, Lieut.-Colonel Donald Stuart, R.A.S.C., B.E.F.
Landau, David, New York, U.S.A.
Lewin, Major Herbert William, R.A.S.C., M.A., London.
Miller, Ernest, Karachi, India.
Oakley, Alan James, London.
Poppe, P. A., Coventry.
Rae, John Turner, London.
Richardson, James Alaric, Newcastle-on-Tyne.
Robb, Alexander, Edinburgh.
Sanyal, Jibon Kumar, B.Sc., London.
Shaw, George Frederick, Belfast.
Siddeley, John Davenport, C.B.E., Coventry.
Smith, Major David J., O.B.E., R.A.S.C., London.
Smith, Leslie Tweedie, Westcliff-on-Sea.
Thomas, Hugh Kerr, Buffalo, U.S.A.
Tucker, William Trueman, Loughborough.
Turrell, Charles McRobie, Tinsley, Sheffield.
Yarwood, Douglas, Northwich.

The candidates proposed at the opening meeting on November 20th, of whom a list was published in the *Journal* of November 22nd (pp. 6 and 7), were duly elected Fellows of the Society.

A paper on "Housing After the War" was read by Mr. B. SEEBOHM ROWNTREE.

The paper and discussion will be published in the *Journal* of December 20th.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Thursday, November 21st, 1918; SIR CHARLES LUCAS, K.C.B., K.C.M.G., in the chair.

THE SECRETARY of the Section announced that the Chairman of the Committee (Lord Blyth) had received the following letter from the Right Hon. W. M. Hughes:—

"I greatly regret that owing to indisposition I shall be unable to be present to-morrow afternoon at the reading of the paper on the Pacific Islands.

"You know my views on the question, and I speak for Australia when I say that their retention by the Commonwealth is essential to our safety."

THE CHAIRMAN (Sir Charles Lucas) said it was a great honour, as it was also a great pleasure, to take the chair that evening for a very old and very great friend, and a very distinguished man. There was no authority on the Pacific higher than Sir Everard im Thurn. For several years he was Governor of Fiji and High Commissioner of the Western Pacific, and won the confidence of white and coloured men alike. He was one of the leading authorities on anthropological questions, and no man had studied more than he had the native races of the British Empire, or had had more kindly sympathy with them. Sir Everard had in hand a great book on the Pacific, but the work had been held up by his manifold activities during the war in connection with the contingents that had come from Fiji, Ceylon and other Colonies. When that book was published it would be the last word on the Pacific question. He thought that what was most in people's minds just now was the future state of the Pacific, and he was delighted to read in the papers that day the very decided tones which had been heard in Australia with regard to the future, and the pronouncement that had been made by the Secretary of State for the Colonies. One and all were determined that, not primarily in their own interests, but primarily in the interests of the native races, no German should rule over any but a German race in the days to come.

The paper read was—

THE PRESENT STATE OF THE PACIFIC ISLANDS.

By SIR EVERARD IM THURN, K.C.M.G., K.B.E., C.B., LL.D.

It seemed to me that at the present great moment in the history of the world a statement by an eye-witness and student of the "present state of the Pacific Islands," and of how they came into that state, might be useful. I do not propose to touch on the surrounding land areas, except in as far as the story of these areas has a bearing on the condition into which "the Islands" had passed at the outbreak of the great war. I want it to be clearly understood that my strictly limited purpose is to draw a picture (it must be a mere sketch) of these remote and mostly small islands, which must shortly receive a small but not unimportant share of attention in the resettlement.

A glance at a specially drawn map of the Pacific Ocean shows it as a vast sheet of water stretching from the Arctic to the Antarctic lands, and almost enclosed, on the east by the whole western shore of America, from Cape Horn to Alaska, on the west (only interrupted by the narrow Behring's Strait) by the eastern shore of the Asiatic-Australasian land mass, from Siberia to New Zealand.

Within the water space thus enclosed lie the innumerable islands with which we are now concerned. With very few exceptions (and none of these here concern us except, perhaps, the Galapagos) the islands are gathered in one great group, most thickly along the east shore of Australia and thence along the equator, tapering to a point towards the American shore. They are, as it were, stepping-stones across from shore to shore, which have been used in the migrations of primitive folk, and are still of great importance as halting places in the passage from shore to shore.

It is of this great group of tropical islands—"the Western Pacific Islands"—that I shall mainly speak this afternoon, for the Hawaiian Islands, though somewhat isolated from the rest, may be considered as yet belonging to the group. Then it may be said that the only other islands of importance in the coming resettlement of the Pacific are the Galapagos (Chilian), which derive importance from the fact that they guard the western end of the Panama Canal.

The next point which it is important to note is that the islands, always excepting New Caledonia, are for the most part individually

small—the greater number, indeed, mere specks, but in many cases (*e.g.* the Solomon Islands, New Hebrides, the Fijis, and others) are so grouped as to give each set of islands almost the value of one large island.

Moreover, in this "Oceania" a mere statement of the length and breadth of an island as shown on a chart may give little idea of its land surface. For instance, in the "Low Archipelago," in the Eastern Pacific, the separate islands, some of considerable extent, are atolls, which, like countless others throughout this ocean, are mere rings of coral rock rising from the bottom of the ocean. In such cases the whole centre of the island is occupied by a lagoon, valueless to its inhabitants, unless its waters contain pearl shell, and only this surrounding rim of rock, often almost bare of soil, affords foothold for land plants.

Again, islands which occupy very little space on the sea surface may be of great value either for economic or strategic purposes. For instance, of the first kind, are Ocean and Pleasant Islands, both of which are solid masses of phosphate rock, and of the second kind is Fanning Island, which, though small in area—and most of that is taken up by its lagoon—is so situated as to be of great importance as a cable station.

There are other reasons which make some islands more desirable than others irrespective of actual size or extent of productive land surface. For instance, the little island of Pago-Pago (in the south of the Samoan group) is of great importance on account of its magnificent harbour. In short, a mere study of the map gives little idea of the comparative value of the islands.

What were the chief natural products of the islands before the intervention of Europeans? The most obvious was the coconut palm, which even then crowned every ledge of rock near sea-level, and had, though more sparingly, spread upward into the miscellaneous plant growth which clothed the slopes of the high islands. It is still a moot point where this palm originated; it was most probably in South America, whence it drifted in past ages across the Pacific. The coco-nut palm, which must always have supplied most of the chief needs of the original islanders, is, as far as I know, the only—or, at any rate, the chief—indigenous plant which has since become of very great economic value to Europeans.

Who were the "Natives" who were found in occupation of the islands when first visited by Europeans? That is a contentious matter, as to which it can here only be said that they were mainly of two types—Melanesian and Polynesian—distinguishable from each other, but yet sharing characters which distinguished them from the folk of other parts of the world. The chief point here to be noticed is that these islanders ("savages," the earliest European visitors miscalled them) had in their isolated island homes evolved for themselves a very considerable "culture" in arts and in social institutions, very different from, and, of course, much less advanced than, the so-called "civilisation" of the world outside our ocean, but yet, in its way, much more advanced than the "culture" to which the "savages" of many other parts of the world had attained.

This indigenous culture of the Pacific Islanders is of importance in the matter now under consideration. The islands being so scattered and isolated it was natural that this culture should have developed in different degrees in different parts of the Pacific. For example, the Melanesian of the Solomon Islands—at first sight a mere naked savage—had developed artistic instincts of a high if special order, in the making, and especially in the ornamentation, of his weapons, and had evolved for himself an elaborate and, in a way, serviceable set of social institutions. Further to the eastward, say in the Friendly Islands, the more stately and—at least on ceremonial occasions—tapa-clothed Polynesians had advanced along not altogether dissimilar lines, but to a much higher stage, both in artistry and in social institutions. Both had attained to a very remarkable degree of primitive "culture"—the Polynesian to a much higher degree than the Melanesian—but both lacked the one thing needful to give them "civilisation" as well as culture.

They lacked, *i.e.* the one idea which is the foundation of civilisation as distinguished from mere culture—the idea and recognition of the dignity and rights of humanity. They were pure egoists (egoism by no means excludes culture of a kind) and had not attained to the idea of altruism—which is the one thing needful to impart civilisation as well as culture.

The natural attitude of the South-Sea Islander towards the white-skinned intruder was from the first and is to-day—so far as this attitude of mind has not been modified by the imposition of the entirely alien idea of altruism—that "everything is mine, as long as I am strong or 'cute enough to take it, and only that is thine which you are able to take from me."

This original attitude of mind of the islanders before they first and suddenly came in contact with civilised men, has necessarily been much blurred and obscured during the century and a half since that contact first took place by the imposition of the ideas of civilised men (based on altruism), but it still more or less persists. The mixture has been, as it were, mechanical and not chemical.

This "mechanical" mixture of two different mentalities accounts for much that would otherwise be unintelligible in the relations of the islanders and the Europeans.

Spaniards, in the great days of Spain, first penetrated into the Pacific, before unknown to the world, and for some two centuries crossed and recrossed its waters, from south-east to north-west, to bring the wealth of the East Indies, by way of Spanish America, to Spain; and in their wake followed the buccaneers and circumnavigators (it is sometimes hard to distinguish the one from the other) to singe the beard of the King of Spain, and to prey on his Royal galleons.

And at a very little later time (1642–43) the Dutch, under Tasman, from Batavia, discovered what we now call Australia and New Zealand, and penetrated into the south-west Pacific as far as the Friendly Isles (Tonga), afterwards making their exit by way of the north of Australia and New Guinea.

But these early Spanish and Dutch enterprises hardly penetrated into what we call "the Islands," and certainly established no friendly nor permanent relations with the islanders.

England rightly claims the chief share in the earliest investigation of the islands, and in the establishment of relations with the islanders. Captain Sam Wallis, of H.M.S. "Dolphin," in 1767, seems to have been actually the first to effect this, by his visit and short stay at Tahiti, living on very friendly terms with the islanders, and thereby first beginning permanently friendly relations between westerners and any of the Pacific islanders.

Two years later Lieut. James Cook, of H.M.S. "Endeavour," revisited Tahiti, early in that long series of voyages in which he and his men made the first real examination of the Pacific Islands as a whole, and of the east coast of Australia.

It is hardly necessary to say that one early and most important result of Cook's work was the establishment of the first European settlement in Australia, *i.e.* Port Jackson, originally intended as a convict station, but which was in reality the small seed from which sprang not only the now great Dominion of Australia, but also its great daughter, New Zealand.

But there is more need to recall, for the fact is more often overlooked, that Port Jackson was the cause which led to the spread of people of European race throughout the islands. For it was this first European settlement in the Pacific that attracted and made possible the South Sea whale and seal fishery, which brought so many ships from the New England Colonies and the Atlantic shore of America into those seas.

Moreover, it was from Port Jackson that the first European trade to the islands originated—for pork and for sandalwood.

The important trade in pork between Port Jackson, which in those early days was always in dire straits for provisions, and Tahiti is a curious story which cannot be told here; but it may be noted that the ships passing for this purpose between Port Jackson and the Tahiti of Captain Sam Wallis played a considerable share in the distribution of white men through the islands.

The sandalwood trade to Fiji claims fuller notice; for though the incident was of considerable importance, it has been almost entirely forgotten. All the reference books repeat the story first told by Missionary Williams (in or about 1858) that "about the year 1804 a number of convicts escaped from New South Wales and settled among the (Fiji) Islands, and that these were the first settlers in that group." Williams adds that these white men gathered together in a small settlement at Levuka in 1815. It is generally added that the first real settlement in Fiji was made by the missionaries from Tonga in 1837.

By a fortunate chance full and detailed evidence has lately come into my possession that from 1804 to 1813 a very considerable number of ships from Port Jackson and from New England visited and lay often for considerable periods at these islands—in Bua Bay in Vanua Levu, not the islet of Bau off Viti Levu—taking in sandalwood, which was cut by the islanders, and that, though the sandalwood trade practically ceased in or soon after 1813, the accessible trees all having been cut down, and the relations between the visiting sailors and the natives having become too strained, a considerable number of white residents were left in the islands, chiefly at Levuka, and generally in more or less friendly relations with the natives.

In passing it may be noticed that after sandalwood had been cleared out from the Fiji Islands, this particular trade passed, first eastward to the Marquesas Islands—not many years after these islands had been exploited by Captain David Porter of the American privateer "Essex"—and then to the New Hebrides, where it still lingers in desultory fashion.

Returning to the case of Fiji as an illustration of the way in which European influence "penetrated" into these islands, after the sandalwood trade ceased, American vessels from New England not infrequently called there on their way to and from China, and between these visits left representatives behind—to collect *bêche-de-mer*—very largely in request to make soup for the Chinaman.

In this way a considerable, and it must be confessed somewhat lawless, body of Europeans—of several nationalities, but mostly English and Americans—became domiciled in the islands among the islanders, the relations between the white men and the natives being usually more or less friendly, but with pretty frequent rows. But it must always be remembered that during this period there was, as far as was known, nothing to be got from the islands except natural produce collected by the natives, and none of it in great request in the markets of the outer world.

I must go back for a moment to Captain Cook's time and the French exploration of the islands, and with it to the scattering of Frenchmen among the islands. Probably these French visits, at first at any rate, were connected with a vague desire of establishing a Terre Napoleon, and were continued that France might do her share of exploring work. Also after French settlers in the islands had become numerous, the French did some keeping of order, mostly by punitive expeditions, when outrages by natives against Frenchmen had been reported.

The French in 1840–42, on the ground of disputes between the French Roman Catholic missionaries and the natives, established a protectorate over Tahiti; and in 1853 they took possession of New Caledonia, as a convict station, thus first establishing their flag in any of the islands.

The fact has already been mentioned that during the first half of last century, New England ships traversed the Pacific more numerously perhaps than those from any other country. The United States of America Exploring Expedition (1838 to 1842), under Commodore Charles Wilkes, was sent as a consequence. His survey of the islands and rocks is complementary to that of Captain Cook, and is the basis of our hydrographic knowledge of the island area. And Wilkes's many-volumed report is by far the most valuable record of the circumstances of the islanders as they were after the first forty years' intimate contact with Europeans.

Meanwhile the Germans, during the period under consideration—it is only fair to remember that it was before the days of United Germany—naturally had not acquired any holding in the Pacific, but, characteristically, had absorbed far more of their share of the trade with the islanders. Up to now the trade had been entirely in natural products, and latterly perhaps chiefly in native-grown coco-nuts. The small German traders were scattered singly or in twos and threes throughout the islands. Most of these came, about 1857, under the influence of the Hamburg firm of John Cæsar Godeffroy & Son, operating from its centre in Samoa very widely through the islands. This company was afterwards reconstructed under the extraordinarily long name of the "*Deutsche Handels- und Plantagen Gesellschaft der Sudsee-Inseln zu Hamburg*." It had acquired much land in Samoa, and it had fallen more or less under Government control, and it probably had much weight in subsequently getting, but not till 1899, Samoa, or rather the main part of it, assigned to Germany.

With the seventies of last century political changes began to occur in that which had so long been the No Man's Land of the Pacific Islands.

Something other than a natural product was found which, for a time at least, could be profitably grown in the Fiji Islands. This was cotton, and men flocked there from Australia and New Zealand, both of which Colonies had long protested vehemently, but till then vainly, that England should annex Fiji, and there establish a stable government in place of the mongrel constitution which had been patched up jointly by the white settlers and the natives under the so-called "King" Cakabou, really only one of the great Fijian chiefs. In 1874, when cotton was failing, and when it was impossible longer to bear with the state of anarchy which had arisen in Fiji, England yielded and accepted the cession to the Crown of this whole group of islands, which henceforward became a British Crown Colony.

Early in the seventies Germany, then recently "united," started a colonial policy, and at any

rate, as far as the Pacific is concerned, it worked by fostering large commercial companies, such as the old-established one whose long name I have already quoted, and other even greater concerns, which it promoted and supported, apparently with the express intention of claiming political rights over all places where these companies gradually acquired preponderating, or even exclusive influence among the natives. When the ground had thus been prepared, it raised its Imperial flag, without protest from any one except the Australians and New Zealanders—who were after all really the most interested parties—over a large part of the Pacific coast of New Guinea and over the large and important adjoining islands of New Britain, New Ireland and New Hanover, all originally brought under some sort of civilised influence by missionaries of British origin, as well as a whole host of the smaller islands and groups of islands which surround these main islands. It has always seemed a work of impudent supererogation that the Germans changed the good old names of New Britain, New Ireland, and the Duke of York's Island to Neu Pommern, Neu Mecklenburg and Neu Lauenburg. The whole of the group which they thus formed for themselves they called the Bismarck Archipelago, though it is more than probable that Bismarck himself would have denied the wisdom of this Imperial new acquisition.

France, though long in power over the "Society Islands," which it is convenient, if not quite correct, to speak of as "Tahiti," did not definitely and finally annex these till 1880–1887.

The United States, though, as in the French case to which reference has just been made, long in real and practical authority, took in the Hawaiian group only in 1898.

Even after all this there were islands, many of considerable size and importance, in which no one Power had complete control, *e.g.* the Solomon Islands and the New Hebrides, in the first named of which British and German influences were mixed; while in the second British and French, the last chiefly from New Caledonia, were inextricably mixed; and much more to the east the Samoan group, in which were British, Germans, and Americans. At last, in 1899, by the treaty of Samoa, these almost last of the then unclaimed islands were assigned. The Solomon Islands became definitely British, except the large but least developed northern island of Bougainville. Of the two tiny islands called Pleasant, or Nauru Island, and Ocean, or Panaba Island, each a valuable lump of phosphate rock, the former was assigned to Germany and the latter to Great Britain. Samoa fell to Germany with the important exception that Pago-Pago, with its almost first-rate and very beautiful harbour, went to America.

Thus the partition of the Pacific was for the time complete, for Tonga, sometimes said to be the last remaining independent native kingdom of the Pacific, is practically under exclusively British protection.

In the strange case of the New Hebrides, by the Anglo-French Convention of 1906, a Condominium of France and England was established.

Let us glance for a moment at the value, strategic and economic, of the share in the islands assigned to each of the Powers concerned.

Germany in Kaiser Wilhelm's Land—German New Guinea—held a strategic position of enormous value for the purpose which she presumably had in view—that is as a naval base to be used against Australia and Japan; and in this same compact group of possessions she had, but hardly used, a very large area of land available for the cultivation of tropical products; a very large area as compared with the total extent of such land in the whole of the other islands. Moreover, in the groups of small islands, or rather atolls, north of the Bismarck Archipelago, she had ample opportunity for the collection of native products; and in Nauru, small as the island is, she had one of the most valuable properties within this ocean. In Samoa she had a property of great potential value, if she had been inclined to develop this, but, owing to its isolation from her other possessions, of no real strategic value. It must have been a bitter pill to her to yield the splendid harbour of Pago-Pago to the Americans, under the Samoan Treaty of 1899.

France had and has New Caledonia, which has always seemed to me potentially the most valuable of the islands of the Pacific. But she took it as a convict station, and has done very little to develop its economic wealth, and now that she has ceased to use it as a convict station, she does not seem to have increased her efforts to develop its great potential mineral riches. In the New Hebrides, where the influence of France runs conjointly with that of Great Britain, her interest seems rather sentimental than real. In the great group of small islands of which Tahiti is the best known,

she has a delightful and romantic possession, but perhaps of no very great economic value. However this may be, in the two small island groups of the Horne and Wallis Islands, she has something that is of value to her only in that they lie midway between New Caledonia and Tahiti.

America, in the Hawaiian Islands, has a splendid economic property, and has developed it to a degree perhaps unknown elsewhere in the Pacific Islands. Its value to her as a half-way house to the Philippine Islands is obvious. The strategic value to America of Pago-Pago is as a naval base.

The British islands are very scattered, but in a sense more valuable to us as being scattered far along the seaway from Australia to America. And, in the Fiji Group and in the Solomon Islands Britain has, for purposes of tropical agriculture, the most valuable asset in the Pacific, perhaps not even excepting the Hawaiian Group.

On the whole, therefore, it seems to me that the partition of the Pacific, as it stood just before 1914, was equitable, except in the one particular that it gave to Germany at least an equal share with the other Powers, though she had done least to earn it, and had, it now appears—Australia always said so—the worst intentions in claiming a share at all.

Then the storm of war broke. I was in Australia on that memorable 4th of August, and for some weeks after; and I know, we all know, how promptly and successfully, the moment the chance came, Australia sprang at the German possessions in and about New Guinea, and how New Zealand did the same for German Samoa. And we know also how readily Japan ousted the Germans from the islands which they had held to the north from New Guinea.

I have never from the first moment been able to conceive the possibility of these very temporary possessions of Germany in the Pacific being returned to her, unless in the still more inconceivable event of a German victory having been achieved. At any rate, all danger of the return to Germany of her colonies is now over.

But what has still to come is the re-partition of the islands. And what may happen in that sorting I do not pretend to prophecy. I have always thought that eventually the whole of what are, and may become, British possessions, must pass into one Australasian Federation, but that the time for that has not yet come. For the present, if the rearrangement were left to me, I would leave Kaiser Wilhelm's Land and the Bismarck Archipelago—of course, changing the names—to Australia; I would leave German Samoa to New Zealand; and I would—for the present—develop a strong Crown Colony out of the Fiji and Tongan groups, with the New Hebrides and all the Solomon Islands, and the Gilbert and Ellice Islands, definitely including with the latter the two phosphate islands of Nauru and Ocean Islands, and I would leave the other small islands away to the north to Japan.

DISCUSSION.

Lord Denman, G.C.M.G., K.C.VO., offered his thanks to the author for his very interesting paper. All present, even, he thought, Sir Charles Lucas, who for so many years served with such distinction at the Colonial Office, would go away wiser for what they had heard that afternoon. He himself was as keenly interested in Australia now as when he had the privilege of addressing a gathering of the Society before he went to Australia as Governor-General nearly eight years ago. Everyone was agreed that whatever else happened no Germans should possess islands or colonies in the Pacific. He thought also people would be agreed that, if only because of the great sacrifices that Australia and New Zealand had made, and the glorious victories their troops had won in the great war, common gratitude demanded that they should, if it were possible, receive some recompense in the way of additional territory or sphere of influence in the Pacific. He spoke with great submission on that point, and with not a fraction of the authority possessed by the author, but it would seem to him a fairly commonsense arrangement that, as Australian troops had conquered German New Guinea, Australia should retain it; that, as the New Zealanders had conquered Samoa and occupied it, New Zealand should keep it; and that Japan should have the islands north of the line. With regard to the New Hebrides, he did not know whether Sir Everard im Thurn would agree with him, but he had some rather detailed information of the state of local affairs, although he had never had the pleasure of visiting the New Hebrides himself. He thought it must be admitted that the condominium system was not entirely satisfactory. No complaints could be made against our French neighbours; he believed the British had always got on just as well with them there as they had on the battlefields of France; but it seemed to him that the condominium had not proved itself a good system when it had been tried in any part of the world. Obviously it must be so, because the condominium entailed divided responsibility, and that could not be good in connection with the administration of the government of native races.

Sir Walter Egerton, K.C.M.G., LL.D., also wished to add his thanks to the author for so

entertaining and interesting a paper. People in the British Isles knew much too little about geography, and even our knowledge of our own possessions required considerable improvement. People who had lived in out of the way parts of the world, as he had, had many instances of that from merchants. Even in British Guiana, one of our oldest Colonies, he had received letters addressed to "The British Consul," and, as was well known, British Consuls did not live in British Colonies. During the reading of the paper he had said "Hear, hear" on the question of the unsuitability of the continuance of the condominium in the New Hebrides. It was not that he thought the French were undesirable partners in ruling those islands: indeed, if he had to choose any foreign nation as a joint ruler with the British he would choose the French. He had seen many of their colonies and the admirable way in which they developed them, and he thought the British Government might take a hint from the French and give more direct assistance to the development of our larger tropical possessions. Although he had travelled a good deal about the world, his travels in the Pacific were limited to a journey between Japan and San Francisco, in the course of which he stayed a few hours at Honolulu, but he quite agreed that the German possessions should not be returned to the Germans. Those who had lived in British Colonies adjacent to German possessions knew long before the war that that nation was unfitted to control any native land. We had been harrowed in the last four years by stories of German inhumanity, and he would not inflict on that meeting others that he could mention with regard to what the Germans, long before the outbreak of the war, did to the natives in the Cameroons, and even to some of those living within the borders of Nigeria.

Mr. B. Glanvill Corney, I.S.O. (late Chief Medical Officer of Fiji), said the natives of the Pacific did not wish to labour if they could live without it, but that was a feature he had seen amongst other people. There was an excellent reason for it there because the natural products of the islands afforded a magnificent food supply, and other materials from which they manufactured their clothing, implements, houses, canoes, and all the necessaries of life. Many features, he was sorry to say, were now disappearing, owing to the rapid grafting upon the native system of the culture and customs of the Europeans living amongst them. There was a great difference between the study of the history of the Polynesian and Melanesian races and that of the races of Europe. In Europe we were accustomed to read records and to look back upon changes that had been going on gradually for two or three thousand years, whereas when we began to examine the history and culture of the Polynesians we found them, as the author had said, ready made up to a certain point, and that point was no more than 150 years ago.

The Chairman (Sir Charles Lucas) said it was a great pleasure in the midst of all the political worries of the time to have a scientific address such as had been delivered that afternoon, with such delightful photographs and charts. Everyone could see that the author loved the natives, and could judge what was to be expected in the book that the author was to publish hereafter. He was very glad to hear what Lord Denman said about the condominium in the New Hebrides, because it was one of the new fads of Democracy that the world could be put right after the war by internationalisation. He did not suppose that anybody who had had anything to do with the condominium failed to see the impossibility of it and the badness of it for the natives. Samoa was another case in point. It would be found in a Parliamentary White-book that, before the final settlement, the islands were under the joint control of Great Britain, Germany, and the United States; but the representatives of the three Powers reported that the position was an absolutely impossible one. People who proposed lightly to internationalise the tropics never seemed to ask whether anything had been done in that way, and, if so, what had been the result; and never seemed to take counsel with anybody, such as the author, who knew the tropics well. He wished the author had had time to say something about the success of East Indian immigration in the Pacific. He himself had the pleasure of staying for some time with Sir Everard and Lady im Thurn, and he was very much struck by the sight of the East Indian immigrants in Fiji. To his mind it was a great pity that the system of East Indian immigration had been given up, because he regarded it as a very great and very beneficial form of colonisation in tropical lands. It would be very interesting to see whether there was any change in the attitude of Australia and New Zealand—not with regard to Australia and New Zealand themselves, but with regard to the Pacific Islands—after the experience they had had of coloured men in the war. He would have been glad, too, if Sir Everard could have pointed out the extraordinary effect of missionary work in the Pacific. He did not think that in books dealing with the Empire enough credit was given to the missionaries, not only for their religious work, but for the work they had done in the extension of the Empire. He did not believe for a moment we should have the estate we had in Central Africa, if it had not been for David Livingstone. Many would say that it was only the camouflage of religion, but that was not so; missionaries were sane and sensible men, who saw that the best safeguard for the natives was to come under British rule and British influence. There seemed a sort of wrong-headed feeling about the settlement after the war, that, if we kept all we had taken, we should be doing a selfish thing, and that we must not appear to be selfish. The thing to consider was what would be the best for the natives of the lands, and he was British enough

to think that they would fare best under Great Britain. He was delighted when the author spoke of the loyalty of the natives. He had been making it his business to read up all the reports, official and otherwise, with regard to native races in this war, and he thought it was the finest testimonial that any country ever had from the beginning of the world, that the native races had rallied with one accord to the side of Great Britain.

SIR H. EVAN M. JAMES, K.C.I.E., C.S.I., in moving a vote of thanks to the author for his most interesting paper, said he only wished that some fortnight hence Sir Everard might be induced to favour the Society with a further address, because there was so much more about the Pacific Islands that he might mention if he had time. He (the speaker) was particularly interested in those islands, as he had visited Papua and the New Hebrides and the Solomons, and he could say from his own knowledge how unsuitable an arrangement the condominium was in the New Hebrides. He would like to know Sir Everard's views as to the prospect of the natives continuing even to exist, as it appeared they were diminishing rapidly. The first island he himself visited had dwindled from a population of 30,000 to 1,500 in the lifetime of a single missionary, and in one island where the French had allowed spirits to be introduced the natives were diminishing with great rapidity.

ADMIRAL THE HON. SIR EDMUND FREMANTLE, G.C.B., in seconding the motion, said he knew of no one so competent to give information about the South Sea Islands and the islanders as the author. His own information on the subject was comparatively small. He spent a commission in Australia and New Zealand, and it was a regret to him that he was never able to visit the South Sea Islands. The author's object was to speak rather of the natives themselves than of the geographical questions of the South Pacific, but he would like to have heard something more about the communications between Great Britain and Australia and New Zealand *viâ* the Isthmus of Panama. Although America had no land in that direction, she was determined that the South Sea Islands should not be in the hands of an aggressive Power like Germany. He thought he was right in saying that it was Dr. Solf, of whom we still heard a great deal, who spoke of regions like Samoa as jumping-off places for the Germans to enable them to dispute the freedom of the seas with Great Britain. That showed pretty clearly the intentions of the Germans and whether they wanted more land or not, the question was whether in the interests of the inhabitants it was not right that the natives should be under a civilising Power like England, and not under an aggressive Power like Germany. It was very much to the credit of our rulers, and especially of the author, that the inhabitants of the Fijis and the native races of that part of the world had been so anxious and ready to do all, and more than all, that was expected of them to assist us in this war. It showed that, after all, Great Britain was the best guardian of the native races. He was glad to hear what the Chairman had said about the influence of missions in connection with the Empire.

The motion was carried unanimously.

SIR EVERARD IM THURN, in reply, said there was a good deal more that he would like to have said, but there was just one omission on his part which Lord Denman had been good enough to point out, and that was with reference to the condominium. He had administered from the British side the condominium for four years and had seen how it worked, and perhaps in that way he was as good an authority on the subject as could be found. He was very friendly with the French High Commissioner, who was Governor of New Caledonia, having stayed with him on several occasions, and the French High Commissioner had stayed with him, and they were very great friends, and got on capitally in the condominium work. Also he visited the New Hebrides on other occasions and went about amongst the French officials, and made great friends with them. Indeed nothing could have been more friendly, but nothing could be more certain to his mind than that the thing could never work, for the reason that French Colonial administration was on absolutely different lines from British administration. He might take, for example, the attitude of the French administrators towards the natives. It might be a perfectly good attitude, and even a better attitude, than that of Great Britain, although he did not think it was; but it was very different from that of Great Britain, and one court common to Great Britain and to France could not possibly treat those natives properly. The condominium system, at any rate in a place like the New Hebrides, was quite unworkable, as he knew from the first it would be.

The meeting then terminated.

CALIFORNIAN FRUIT EXPERIMENTS.

Details are given in a recent issue of the monthly *Bulletin* of the California State Commission of Horticulture of various experimental projects of the State University in regard to fruit.

There are now on the experimental farm fifty-five acres of fruits used for experimentation and instruction. Experimental investigations cover pruning studies with young and old apricot trees, different methods of pruning bearing prune trees, pruning young and bearing peach trees, pruning of old and young apple and pear trees, training and shaping young apricot, cherry, plum, prune, peach, and pear trees. Experiments in the summer pruning of both young and old trees are also being conducted.

An experiment in orchard irrigation is being

carried on at Davis in co-operation with the irrigation division of the University. Peaches are being studied first; later, other fruits will be added. One of the larger long-time experiments is being carried on at Davis to determine the best or most profitable distance apart for planting apricots, cherries, peaches, pears, plums, and prunes. The yield record of the orchard, covering a period of fifteen or twenty years or longer, will determine the best or most profitable planting distances.

The cold storage studies with deciduous fruits are being carried on at Berkeley. These include the keeping qualities of grapes held at different cold storage temperatures, keeping qualities of pears in cold storage, and the keeping qualities of apples in cold storage as affected by the health and vigour of the trees and also by the stage of ripeness at harvesting time. The new Agricultural Building, Hilgard Hall, at Berkeley, has the best experimental cold storage plant in the United States.

Six new projects deal with fruit-drying problems. These include a survey of the fruit-drying industry of the State, variety tests of fruits for drying purposes, standardisation of fruit-drying methods, equipment for drying, effects of finishing in the shade by stacking the trays, and effects of sulphuring on fruit tissue and its possible relation to palatability of product. Extensive data along these lines were collected during the last season.

VENEZUELAN PRODUCTION OF BALATA.

Balata, a gum similar to gutta-percha, is largely used in the manufacture of belting. It is obtained from the sap of *Mimusops globosa*, a tree reaching 100 feet or more in height, which is widely distributed over eastern Venezuela and the Guianas. The latex is secreted between the bark and the wood of the tree; it contains nearly equal proportions of resin and gutta, the latter being identical with true gutta-percha.

The word "balata" is of Carib origin, and is used by the natives of British, Dutch and French Guiana, as well as by those of Venezuela, but it is applied solely to the gum, the tree being known as the purguo. On the coast between Puerto Cabello and Cape Codera the tree is called the nisperillo.

According to a report by the United States Consul at La Guaira, the commercial exploitation of this tree in Venezuela began near Maturin, where, by 1894, it had already been exterminated. Sap collecting was then begun near San Felix, in the State of Bolivar, and as the tree became scarcer the area of operations was extended eastward to the boundary of British Guiana and southward along the Orinoco and its tributaries to all accessible regions. In Venezuela the custom is to cut down the trees in order to obtain the sap, and the industry has thus been progressively destroying itself. A Governmental commission estimates that in the last ten years alone the 10,000 collectors have destroyed 36,000,000 purguo trees, and that the direct loss to the nation from this cause amounts to a very large sum of money. In spite of the fact that in British and Dutch Guiana felling is prohibited, and that regular production of latex is obtained by tappings that do not kill the trees, the merchants of Ciudad Bolivar have opposed any governmental prohibition of the cutting down of trees, arguing that in whatever manner the tree is cut it will die, and that there is no better method of obtaining the latex than felling.

The purguo is of slow growth, the period required for a tree to reach the productive stage being more than ten years, and full development not being attained for thirty years or more. The fruits, being agreeable in taste, are nearly all eaten by wild animals, so that natural reproduction is slow. The trees usually grow at the foot of hills where the soil is fertile and moist, but not water-logged, always scattered among other species and never densely. Land on which there are sixteen purguos to the acre is considered rich.

The balata harvest begins in May and ends in August, but in years of continuous rains work may be carried on at all times, except when the tree is in flower, the sap being then so poor as not to be worth gathering. The collector leaves his camp at 5 a.m., fells the first tree he finds, and makes four cuts on each side of the fallen trunk, to each of which he attaches a tin receptacle to catch the flow of latex. Having worked two trees he returns to his camp about noon, carrying the product of his toil in a bag waterproofed with the same sap. The contents of the bag are emptied into a larger receptacle. On Saturday all the collection of the entire week is coagulated by cooking, and afterwards the gum is pressed in wooden moulds into slabs weighing from 50 to 100 lb.

Under present methods the average production per tree is three gallons of latex, producing 18 lb. of balata worth from 7*d.* to 1*s.* 8*d.* a lb. By tapping properly it is estimated that each tree would produce latex worth about 8*s.* each year for thirty years or more.

For a number of years balata, ranking immediately after coffee and cocoa, was third in importance among Venezuelan exports. The amount and value of the shipments from 1905 to 1916 were:—

	Metric tons.	Dollars (U.S.).
1905	1,461	755,400
1906	1,280	863,830
1907	1,545	1,128,595
1908	1,465	1,149,600
1909	1,650	1,283,575
1910	1,903	2,193,800
1911	2,222	2,449,070
1912	1,698	1,767,260
1913	2,219	2,032,870
1914	894	698,625
1915	1,069	789,325
1916 (six months)	287	229,215

The war has caused great changes in the course of the trade in Venezuelan balata. During 1913 Germany led among the buyers of the gum on the Ciudad Bolivar market, France ranked second, the United States third, and Great Britain fourth. In 1914 the United States rose to first place, followed by France, Germany and Great Britain in the order named. In 1915 Great Britain occupied first place, the United States was second, and France was third, Germany disappearing from the list. In January to June 1916 Great Britain and the United States again ranked first and second, respectively, and France and Germany were both missing from the list.

In 1906 the price of balata in Ciudad Bolivar reached the then high mark of 1*s*. 5½*d*. a lb.; the average price is between 7*d*. and 10½*d*. a lb. The best price in 1915 was about 1*s*. a lb., but an official tariff issued last year by the Ciudad Bolivar custom-house fixed the official valuation of balata at 5 bolivares per kilog, or about 1*s*. 10*d*. a lb.

ENGINEERING NOTES.

New Type of Water Turbine.—Starting from the consideration that there is a gap between the Poncelet waterwheel and the Francis turbine, Donat Banke has experimented with a somewhat novel style of turbine of simple construction, which may be described as a waterwheel with internal flow. The wheel has a horizontal shaft, and is provided with buckets all round. The water enters the buckets through guide vanes on the one side, about 90° from the vertical axis of the wheel, flows through the hollow interior of the wheel, and passes into the buckets on the side, from which it is then discharged. With proper adjustment of the vanes and curvature of the blades, the movement of the water through the buckets on both sides, entering and leaving, and through the wheel, should take place on regular stream lines without shock, and a high efficiency should be realised. Further particulars are given in the *Zeitschrift Verein Deutsch Ingenieure* of August 3rd, 1918.

Increased Weight and Efficiency of Rails.—Railway practice in pre-war times showed a tendency to increase the weight of rails, according to the *Railway Gazette* of September 6th. This tendency has been accentuated by the heavy traffic and great increase in wheel-loads, due to war conditions of the last four years. In the United States in the last twelve months many of the railroads have used sections considerably over 100 lb. per yard. One of them is now contemplating the adoption of 200 lb. steel rails. The railroads employing sections in excess of 100 lb. report great reduction in the cost of track maintenance and the number of failures, as well as securing a better running track. Experiments with heat-treated rails have shown results indicating that they also may have a future. Many experiments have been made in the quenching and annealing of rails which, when put in service, have shown marked resistance to abrasion. Some failures have occurred owing to brittleness. There are, however, heat-treated rails now in service and carrying heavy traffic under severe conditions, which have not developed that weakness. Records of performance in service of different types and weights of rails are of comparatively little value in the absence of data giving the ton-mileage carried by the rail before it failed. It is probable that the standard distance of 42 in. now prescribed in the specifications will have to be increased to meet the necessities of the heavy rails towards which the railroads are tending.

Grain Elevators for South Africa.—The report now issued by the General Manager of Railways and Harbours, Pretoria, states that the Grain Elevators Committee has recommended the erection of an elevator at Durban of 30,000 tons, one at East London of 20,000 tons, and another at Cape Town of 20,000 tons, involving a capital expenditure of £490,000, and also the erection of one "Country Elevator" at each of sixty-two inland centres, the sizes varying according to the tonnage of maize at these stations.

Spitzbergen's Minerals.—The *Morning Post* of October 2nd writes: "In the Treaty of Brest Litovsk there is a significant clause to the effect that Germany should be allowed to proceed with the complete 'organisation' of Spitzbergen in accordance with German proposals. What was exactly meant by this clause is a matter of speculation, but it is presumed that Germany's purpose was, in co-operation with Russia and Finland, to secure access to the ice-free port of Kola, by way of the Murman railway, and thereby establish independent communication with Spitzbergen, where, according to expert reports, are to be found the richest and largest undeveloped coal and iron deposits in the world. If that was Germany's purpose, it has been frustrated by the action of the Allies in taking possession of Kola (the terminus of the Murman railway) and by the action of the British Government in assuming effective occupation of the principal ports and a large part of the habitable area of Spitzbergen by means of an expedition, which was despatched by the Northern Exploration Company, Limited, under the authority of the Foreign Office two or three months ago, and which is now permanently established in Spitzbergen. This expedition was under the control of Mr. Salisbury Jones, managing director of the company. Questioned as to the climatic conditions of the country, Mr. Jones said that they were healthy in the highest degree, particularly on the western side, where most of the British properties were; the cold was dry and bracing, and mining operations could be carried on in comfort for at least six months out of the year. As for transport facilities, there were deep and sheltered ports, only 400 miles from Norway and 1,200 miles from North Britain. Already this year upwards of 120,000 tons of shipping had been employed in the transport of coal from Spitzbergen to Sweden and Norway."

Electric Heating Device.—A novel electric heating system has been installed at a school in Baden, the arrangement being such as to enable the heat to be stored up during the night, when the generating station is lightly loaded, and to be used for heating purposes in the daytime, says the *Electric Review.* The installation utilises the existing hot-water system and radiator. A water container of about 15,000 litres capacity, surrounded with an effective heat insulation, is used for heating the water. Inside this container electric resistances are built that raise the temperature of the water to 110° C. during the night. The hot water can be circulated through the system of pipes, its speed being regulated by a valve. The quantity of water in the reservoir is sufficient to keep up the circulation of hot water all day long without switching on the current. Provision against overheating is afforded by a thermostat. The supply is taken from a 2,000 volt network, and the voltage is transformed down to 220 volts. The total power taken is 100 to 120 kilowatts. The advantage of the system consists in storing heat at a time when the energy is cheap, and then using a portion of the water power that is usually run to waste at night time.

The Use of Acetylene for Rail-cutting.—According to the *Railway Review* there was recently much trouble from the creeping of rails on a trestle belonging to the Chicago, Milwauki, and St. Paul Railway. The result was that the track kinked out of alignment. The usual remedy was to replace certain rails by shorter lengths. This was difficult owing to the frequency of the services, which only allowed of four minutes for the complete operation. The difficulty was further increased by the fact that the "creep" had at times jammed rail-ends so tightly together, that it was not easy to remove the rail even after the spikes had been pulled. It was decided accordingly to shorten the rails *in situ*, by cutting out pieces by means of the acetylene torch. With the torch it was found that the rail could be cut clean across in one minute. The acetylene torch was also used for cutting fresh bolt-holes, an operation effected in fifty seconds.

Insulated Truck for Australia.—Giving evidence in Sydney before the Royal Commission which is inquiring into matters connected with Homebush abattoirs, Mr. Fraser, Chief Railway Commissioner, announced that the chief mechanical engineer of the Railway Department had been trying to design an insulated truck for the carriage of meat on the principle of the thermos flask. Such vans, it was stated, would be easier to keep clean than the vans in use at present. Mr. Fraser said he considered an extra 10 per cent. would cover the cost of providing these insulated trucks, but unfortunately the materials for their construction are not available at the present time.

High-speed "Tubes" for London.—Surveys had recently been made for the construction of two new high-speed tube railways, one from the Crystal Palace to the Strand, and the other from the Oval to Cricklewood, said Mr. Kearney, at the Railway Club on October 8th. The two tubes (run mainly by gravity on the "switchback" system) would be connected at the Oval. Only twelve minutes would be taken on the journey from Cricklewood to the Oval, with eleven stoppages, while the distance from the Crystal Palace to the Strand would be covered in ten minutes with seven stoppages. There was also a proposal for a "tube" between East Ham and Woolwich, making the journey of over half a mile in fifty seconds. A single tube would be built, in which one train would run backwards and forwards, providing for a service in either direction every two and a half minutes.

OBITUARY.

George Pringle Rose, C.I.E.—Information has been received of the recent death of Mr. George Pringle Rose, who was elected a member of the Royal Society of Arts in 1900.

Born in 1855, he was educated at the University of Aberdeen and Cooper's Hill R.I.E. College. In 1877 he became assistant engineer, Indian State Railways. From 1884 to 1887 he was engaged on the construction of the Sind-Peshin Railway, and he received the thanks of the Government of India for his skill and resourcefulness in overcoming the engineering difficulties encountered in this task. He was then selected as superintendent of works for the Sind-Peshin Extension Railway from Quetta to New Chaman, and for his success in this difficult engineering work he again received the thanks of the Secretary of State, the Viceroy, and the Commander-in-Chief of India, as well as the honour of C.I.E.

After serving for a time as Deputy Manager of the North-Western State Railway, Mr. Rose became Adviser on Railway Policy to the Nizam's Government, and he was in charge of the survey operations and construction of the Hyderabad-Godavery Valley Railway from 1896 to 1900. He then was appointed Junior Consulting Engineer for Railways, at Calcutta, to the Government of India, and he retired in 1904.

GENERAL NOTES.

Mineral Resources of the United Kingdom.—An exhaustive and valuable report made to the Minister of Munitions by the late Controller of the Department for the Development of Mineral Resources in the United Kingdom, Sir Lionel Phillips, has been published as a Parliamentary paper. He recommends the organisation on suitable lines of a Mines Department for the United Kingdom, aided by at least three committees or commissioners, one to form a link with the self-governing

Colonies, another to watch and foster the interests of the Empire in the output and trade in mineral and metallic products, and the third "to take action in cases of improper exploitation of properties or unreasonable or prohibitive conditions imposed by landowners for royalties and wayleaves." Although the general prosperity of the industry during the early part of the nineteenth century is hardly likely to be revived, says the report, a very substantial increase in the production of certain minerals could be profitably maintained under improved conditions. To show the extent to which British mining was formerly carried on, several striking facts are mentioned. Firstly, in Cardiganshire alone over 260 mines were in operation at different periods during the past hundred years, while only nine are now actually working. Secondly, in 1872 there were in Derbyshire 194 mines producing lead ore, whereas there are at the present time not more than half a score. Thirdly, in 1856 the number of mines producing tin, lead, copper, and zinc in Cornwall was 259; to-day only 38 are in operation, and they are confined to the production of tin, arsenic, and wolfram, there being no output of copper, lead, or zinc in the Duchy.

WOMEN AND ENGINEERING.—In a letter to *Engineering* (November 22nd) Miss Rachel M. Parsons mentions that several women, who have taken engineering degrees at the universities, are now engaged, in connection with engineering and aeroplane work, in mathematical calculations. With regard to the employment of women in the drawing office, a subject of recent controversy, she says it is true that, until a few years ago, they have been debarred from obtaining the necessary shop experience, but this does not apply to the same extent to some of the calculating work which in many firms is carried on in connection with the drawing office.

HYDRO-ELECTRIC DEVELOPMENTS IN NEW ZEALAND.—H.M. Trade Commissioner in New Zealand, in his latest report, predicts an era of hydro-electric development on a large scale in the Dominion. Apart from the schemes definitely proposed, of which he gives some details, other districts are pressing for works to meet their needs. "I cannot," he says, "too strongly urge upon firms at home the desirability of watching this development closely, in order that they may get a reasonable share of the work which will be offering. It is believed here fairly widely that foreign firms have practically a monopoly of experience in high tension water-power schemes. Foreign firms, too, are well represented and have been able to consolidate their position in the market during the war. Consequently, if British firms are to obtain a reasonable share of the business which will undoubtedly offer, it will be necessary to show considerable activity."

MEETINGS OF THE SOCIETY.

ORDINARY MEETING.

Wednesday afternoon, at 4.30 p.m.:—

DECEMBER 11.—MAJOR-GEN. SIR FREDERICK SMITH, K.C.M.G., C.B., F.R.C.V.S., "The Work of the British Army Veterinary Corps at the Fronts." The DUKE OF PORTLAND, K.G., G.C.V.O., will preside.

CANTOR LECTURES.

Monday afternoons, at 5 p.m.:—

JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." Three Lectures.

Syllabus.

LECTURE II.—DECEMBER 9.—The *rôle* of the catalyst from the standpoint of physical chemistry—Catalysts in solution and in solid form—Catalysis in industry—Hardening of fats—Surface combustion—Oxidation of ammonia—Enzyme action—Acetaldehyde from acetylene.

LECTURE III.—DECEMBER 16.—Physical chemistry of the absorption of gases and dissolved substances—Solubility of gases in liquids as affected by pressure—Storage of acetylene—Charcoal as an absorbent of gases—Production of high vacua—Absorption of colouring matters from solution—Fuller's earth and charcoal—The dyeing process—Adsorption in soils.

Papers to be read after Christmas:—

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S. (Subject to be announced later.)

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

FREDERICK WILLIAM KEEBLE, C.B.E., M.A., Sc.D., F.R.S. (Director of Horticulture, Food Production Department), "Food Production by Intensive Cultivation."

B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

A. F. KENDRICK, Department of Textiles, Victoria and Albert Museum, "English Carpets."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

LIEUT.-COLONEL H. G. LYONS, D.Sc., F.R.S., "Meteorology during and after the War."

W. L. HICHENS (Messrs. Cammel Laird & Co.), "The Wage Problem in Industry."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

J. J. CROWLEY, D.Sc., "The Use of Electricity in Agriculture in Germany."

SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

PROFESSOR JOHN CUNNINGHAM MCLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

SANDFORD J. KILBY, "Indian Salt Manufacture."

H. KELWAY-BAMBER, M.V.O., "Coal and Mineral Traffic on the Indian Railways."

PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Exhaustion in India and its Influence on the Value of Crops."

THE RIGHT HON. LORD MONTAGU OF BEAULIEU, C.S.I., V.D. (Subject to be announced later.)

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

January 16, February 13, March 13, April 3, May 15.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

February 4, March 4, May 6.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m. :—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "Liquid Drops and Globules." Two Lectures.

January 1 and 8.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DECEMBER 9...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Cantor Lecture.) Professor James B. Philip, "Physical Chemistry and its bearing on the Chemical and Allied Industries." (Lecture II.)

Farmers' Club, Central Hall, Westminster, S.W., 4 p.m. 1. Annual General Meeting. 2. Mr. W. A. Haviland (Secretary), "The Report of the Agricultural Policy Sub-committee of the Reconstruction Committee."

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m.

Geographical Society, Burlington-gardens, W., 8 p.m. Sir Martin Conway, "The Political Status of Spitzbergen."

TUESDAY, DECEMBER 10...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture I.)

Britain and India Association, Caxton Hall, Westminster, S.W., 7 p.m. Mr. Bhupendranath Basu, "Womanhood in Hindu India."

Labour Co-partnership Association, Kingsway Hall, Kingsway, W.C., 4.30 p.m. Mr. E. O. Greening, "Godin's Iron Foundry at Guise."

Colonial Institute, Central Hall, Westminster, S.W., 8 p.m. Sir Sidney Lee, "Raleigh's Discovery of Guiana."

Secretaries' Association, Winchester House. Old Broad-street, E.C., 7.15 p.m. Miss Mary Petherbridge, "The Woman Secretary."

WEDNESDAY, DECEMBER 11...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Major-General Sir Frederick Smith, "The Work of the British Army Veterinary Corps at the Fronts."

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, E.C., 4.30 p.m. Sir William M'Cormick, "Science and Industry."

Aëronautical Society, Central Hall, Westminster, S.W., 3 p.m. Mr. C. G. White, "Civil Aerial Transport—Is it Practicable, is it Safe, and is it Profitable?"

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Dr. G. E. Pritchard, "The Organisation and Administration of Child Welfare Centres."

Archæological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Professor F. M. Simpson, "The Cathedrals of the Marne-Aisne District."

THURSDAY, DECEMBER 12...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture II.)

Royal Society, Burlington House, W., 4.30 p.m.

China Society, School of Oriental Studies, Finsbury-circus, E.C., 3.30 p.m. Miss A. M. B. Meakin, "Social Life in Central Asia."

British Academy, in the Theatre, Burlington-gardens, W., 5 p.m. Dr. A. Cowley, "The Hittites." (Lecture I.)

Historical Society, 22, Russell-square, W.C., 5 p.m. "Some British and Allied Archives in War-Time." Communicated by the Director (England and Wales), Mr. R. K. Hannay (Scotland), Mr. H. Wood (Ireland), Monsieur C. Bemont (France), H. E. Cardinal Gasquet (The Vatican), Dr. J. S. Jameson (United States of America).

FRIDAY, DECEMBER 13...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture III.)

Astronomical Society, Burlington House, 5 p.m.

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, Westminster, S.W., 6 p.m.

SATURDAY, DECEMBER 14...Chromatics, International College of, Caxton Hall, Westminster, S.W., 3 p.m. Mr. W. G. Raffé, "The Rainbow in Business."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—December 6, 1918.

No. 3447. DECEMBER 13, 1918. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,447. VOL. LXVII.

FRIDAY, DECEMBER 13, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 16th, at 5 p.m. (Cantor Lecture.) JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." (Lecture III.)

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, December 9th; The Hon. RICHARD CLERE PARSONS in the chair. PROFESSOR JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., delivered the second lecture of his course on "Physical Chemistry and its Bearing on the Chemical and Allied Industries."

The lectures will be published in the *Journal* during the Christmas recess.

JUVENILE LECTURES.

The usual short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, January 1st and 8th, at 3 p.m., by Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, on "Liquid Drops and Globules."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

FOURTH ORDINARY MEETING.

Wednesday afternoon, December 11th, 1918; His Grace the DUKE OF PORTLAND, K.G., G.C.V.O., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Armstrong, P. A. E., Watervliet, New York, U.S.A.
Gow, Charles, London.
Hunter, J. A., Halifax.
Janney, Reynold, New York City, U.S.A.
Latham, Thomas Paul, Weybridge.
Matthews, Mortimer, Cincinnati, Ohio, U.S.A.
Mullett, W. C. B., Wexford.
Parsons, Arthur David Clere, B.A., Stocksfield, Northumberland.
Sharwood, James Allen, Worcester Park, Surrey.
Thomas, John Godfrey Parry, Leyland, Lancashire.
Walker, Harold Gibson, Whitby.
Wans, Oswald, Assoc.M.Inst.C.E., M.I.Mech.E., Lincoln.
Weeks, Herbert Thomas, Tunbridge Wells.
Wenger, Albert Francis, Stoke-on-Trent.

The following candidates were balloted for and duly elected Fellows of the Society:—

Coleman, George, London.
Kindersley, Sir Robert Molesworth, K.B.E., Abbots Langley, Herts.
Lechertier, Jules Eugene, London.
Little, G. W., Manchester.
Paisley, John, Glasgow.
Peacock, E. R., London.
Stone, Edward William, Surbiton.
Trotter, Miss Jacqueline Theodora, London.

A paper on "The Work of the British Army Veterinary Corps at the Fronts" was read by MAJOR-GENERAL SIR FREDERICK SMITH, K.C.M.G., C.B., F.R.C.V.S.

The paper and discussion will be published in the *Journal* of December 27th.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, November 28th, 1918; The Most Hon. the MARQUESS OF CREWE, K.G., in the chair.

THE CHAIRMAN, in introducing the author of the paper, said that Mr. Basu was well known as a distinguished Indian statesman and public man. Indian affairs were very much before this country at the present time, from many points of view, but Mr. Basu's paper would be altogether free from politics. It would, indeed, at any time be of interest to Europeans to hear a first-hand account of some of the features of Indian life from a gentleman like Mr. Basu, but there were special reasons why at the present moment such a survey became of double interest. The people of this country had all been full of admiration and gratitude for the services of Indians in the war. The contribution of India in men alone, to speak of nothing else, had been simply magnificent. The great successes in Mesopotamia, and the great successes in Palestine in their later stages, had for the major part been conducted by Indian troops, and therefore those present would surely have an added interest in hearing from so skilled an exponent as Mr. Basu something that they did not know of the everyday home life of those men. It was, of course, true that India was a vast country, and even Mr. Basu did not know the inner life of the whole of it, but he thought it would be found that, in speaking of Indian home life, and allowing for the countless differences of detail among the different Indian races, much of what Mr. Basu said would, in its general bearing, be applicable to all classes and castes in India, and, broadly speaking, it would not be less true of the Mohammedan than of the Hindu, although it was of the Hindu that Mr. Basu would primarily speak.

The paper read was—

SOME ASPECTS OF HINDU LIFE IN INDIA.

By BHUPENDRANATH BASU,
Member of the Council of India.

I have chosen as the subject of my paper "Some Aspects of Hindu Life in India." I shall not dwell on those aspects of our life which lie on the surface and which are, more or less, known to the European sojourner in India. My story may not appeal to those whose imagination about countries to the east of a certain longitude is coloured mostly by the old-world romance of the "Arabian Nights" or the modern glamour of Kipling. To these it may sound like dripping waters over an unfamiliar soil. But though my story may lack the elements of romance and poetry, I hope it will not be altogether uninteresting; it relates to a life which has been flowing in a continuous though much broken stream, through the long glades of time where the dim past mingles its shadows with the living present, and imparts to it a mellowed and sanctified charm.

From nearly all seats of past civilisation the old life has vanished, but not yet from India. May I for a moment pause on this wonderful vitality of the life into the interior of which I shall ask you gently to follow? I do not propose to detain you long. But this feature of Hindu life must strike even a most casual observer. It is not explained by merely saying that the East is East, for the meridians are merely physical and not psychological lines. You must search deeper. The Hindu is no aggressive proselytiser; he has, indeed, admitted many communities into the folds of his faith, but he has never tried to force its unwilling acceptance. He has a well-defined mental attitude as regards other faiths. He has never believed that because his faith is best suited to him, therefore other faiths of other peoples must be false. He has never professed to be the sole bearer of an exclusive charter to salvation; he has never massacred, burnt or tortured men or women because they belonged to a different faith; he has given safe asylum to the persecuted of all faiths, ancient Jews, early Christians, and Parsis.

While appreciating good in others, he has adjusted his own beliefs and practices to his own requirements, and never found it necessary to renounce them. There is another trait in the Hindu character which is very strongly marked. The Hindu has realised probably in a far greater degree than any other people the faith of Ecclesiastes, and in his belief that all is vanity lies both his strength and his weakness, his salvation and his ruin. Standing here in the centre of the workshop of the world, it is difficult to say who is right. The Kaiser has gone, but it remains to be seen whether Kaiserdom has vanished, or is going to be transferred from one to the many, for democracies may be quite as unjust and oppressive as autocracies. The Western nations think that they have successfully solved the problem of life. The question is will that solution stand the verification of time? We in India have also solved, or attempted to solve, that problem in our own way. India learnt long ago that man doth not

live by bread alone, and therefore she has weathered the storms which through many centuries have blown across her wide expanse, ruffling only the surface of her life. An understanding of these traits of the Hindu character—toleration towards other faiths and detachment from the world, being in it but not of it—are valuable equipments to the traveller who wants to tread the corridors that lead into the inner chambers of Hindu life.

At the entrance you meet that venerable structure—the joint family system. It has descended to us from time immemorial, the patriarchal system of old still holding sway in India. The structure, though ancient, is still full of life. The joint family is a small co-operative corporation, in which men and women have a well-defined place. At the head of the corporation is the senior member of the family, generally the eldest male member, but not unoften, in his absence, the senior female member assumes control. All able-bodied members must contribute their labour and earnings, whether of personal skill or agriculture and trade, to the common stock; weaker members, widows, orphans and destitute relations, all must be maintained and supported; sons, nephews, brothers, cousins, all must be treated equally, for any undue preference is apt to break up the family. We have no word for cousins—they are either brothers or sisters—and we do not know what are cousins two degrees removed. The children of a first cousin are your nephews and nieces just the same as the children of your brothers or sisters. The family affections, the family ties, are always very strong, and therefore the maintenance of an equal standard among so many members is not so difficult as it may appear at first sight. Moreover, life is very simple. Until recently shoes were not in general use at home, but sandals without any leather fastenings. I have known of a well-to-do middle-class family of several brothers and cousins who had two or three pairs of leather shoes between them, these shoes being only used when they had occasion to go out, and the same practice is still followed in the case of the more expensive garments, like shawls, which last for generations, and with their age are treated with loving care, as having been used by ancestors of revered memory.

The joint family remains together sometimes for several generations, until it becomes too unwieldy, when it breaks up into smaller families, and you thus see whole villages peopled by members of the same clan. I have said that the family is like a small co-operative society, and it may be likened to a small state, and is kept in its place by strong discipline based on love and obedience. You see nearly every day the younger members coming to the head of the family and taking the dust of his feet as a token of benediction; whenever they go out on an enterprise, they take his leave and carry his blessing. To a Hindu the blessing of the father is like a talisman; for has it not been said of him in our old Scriptures that "the father is heaven, the father is religion, the father is the realisation of the highest penance; if the father is pleased, all the gods are pleased"? But because the father is an object of reverence, he is by no means a distant and forbidding divinity, for on him is laid the injunction that when the son attains the age of sixteen he is to be treated as a friend. Next to the father is the eldest brother, for when the father goes, he takes his place as the head of the family. A beautiful story is told in the Ramayana, one of our great epics, that when Rama, the eldest son of King Dasaratha, who had died, was in exile, his younger brother ruled the State in his name, keeping his sandals on the throne as the emblem of his authority, and when Rama returned to his kingdom after fourteen years of exile, his younger brother came out to meet him at the city gates carrying the sandals on his head.

I have spoken of the father and the eldest brother. I find it difficult to convey to you an adequate impression of the position that the mother holds in regard to her son. Is not God himself worshipped as the great mother? To the son the mother is of greater consideration than the father, for is not Siva the great father shown lying prostrate at the feet of Kali, the mother spirit of the Universe? On leaving home, on returning after an absence, on festive occasions, it is our custom to go to our elders, both men and women, and pay our respects to them, not shaking hands as is the custom here, but bowing our head and taking the dust of their feet when they pronounce their benedictions. If there are several persons present, the obeisance is rendered to them according to their seniority; but if the mother is there, to her we bow first of all, even if members older than the mother may be present. You can repay all services, all kindnesses, either by money, or service, or love, or devotion, but a mother's debt you can never repay. Those of you who have been to India and visited Benares, must have noticed the leaning turrets

on the banks of the Ganges. Benares is the holiest city of the Hindus, and temples erected there were considered as earning great merit for both those who built them and those in whose memory they were built. Tradition says that these turrets are the remnants of a Hindu temple which a dutiful son erected to the memory of his dead mother, believing that he would thereby repay the debt which he owed to her. When the temple was completed after several years, for you can even now see it was a great temple of stone, and was about to be consecrated, the son was filled with the pleasure which comes of a duty discharged, and he cried out: "Now, mother, I have after all been able to repay my debt to you," and lo! and behold, the temple began to lean towards the earth and was about to fall, when the pious builder, remembering his blasphemy, exclaimed: "Oh, mother, that art in heaven, truly I am sinful, for how can I think of repaying my debt to thee!" and the fall of the temple was arrested, but the leaning turrets still preach a great lesson to devout Hindus who visit Benares. I might give you other stories, but time presses and one will suffice as an illustration.

There are other bonds which bind the family together: the bonds of sympathy, of common pleasures, of common sorrows. When a death occurs all the members go into mourning; when there is a birth or a wedding the whole family rejoices. Then above all is the family deity, some image of Vishnu, the preserver; his place is in a separate room, generally known as the room of God, or, in well-to-do families, in a temple attached to the house, where the family performs its daily worship. There is a sense of personal attachment between this image of the deity and the family, for the image generally comes down from past generations, often miraculously acquired by a pious ancestor at some remote time. You may smile at our simple faith; but there we are in the midst of our daily life, amidst our joys and sorrows, amidst festive weddings and mournful funerals, in constant contact with the Divine Presence symbolised by the image; and the home to the Hindu becomes sanctified as the house of his God, where sinful thoughts would be a sacrilege. In the early morning you see the girls of the family dressed in pure silken clothes bringing to the little temple offerings of flowers with the soft dew of the night still on them, and fragrant sandal paste. You see them cleaning the temple with their little hands, and making patterns of carpet on the floor with dry paint gathered from flowers. The scent of the flowers, of the sandal paste, and of burning incense fills the house; the elder women come after their morning ablutions, clad in fresh clothes, and see that everything is in order; then the priest comes, little lamps filled with butter are lighted, the conch shell sounds, the bell rings, and the worship begins; and men and women all come and bow their heads in prayer and in meditation. Sometimes children make a noise and disturb the worship, and mothers hush them into silence; but though we mere mortals are disturbed in our prayers by the noise of children, our family deity loves them, and sometimes he reveals himself to the mothers in dreams and tells them not to scold the children, for he loves to be in their midst and hear their voices. I know of an instance where, in a well-to-do family, the temple stood a little apart from the house. The family deity appeared to the master in a vision, and bade him build a temple in the inner courtyard, where the children might play round him. These form the nexus of the Hindu family—the father, the mother, the family deities.

With the household gods is intimately associated the family priest, so obnoxious to the superficial critic, for does not the priest live as a parasite on his flock? I have not much intimate knowledge as to how priests are maintained in European countries; probably a priest would be looked upon as a parasite in any country where exchange is thought of in terms of material goods; but men do not live by the rules of the market-place, and souls are not weighed in the balance of trade; and I trust, even in the countries from where men and women go on mission work, priests are not looked upon as marketable commodities to be shipped to distant parts. The Hindu priest is a member of the village community, and is a part of the family life of his flock, between whom and himself the tie has existed for many generations. The priest is not generally a man of much learning; he knows, however, the traditions of his faith, and, in spite of his ignorance, is the unconscious inheritor of a high degree of spiritual culture and lives up to the ideals of his priestly profession — poverty and service. He is not a very heavy burden, for he is satisfied with little—a few handfuls of rice, a few home-grown bananas or vegetables, a little unrefined sugar made in the village, and sometimes a few pieces of copper are all that is needed. There are no tithes, no state grants.

The Hindu family priest may have his faults, for the perfect man is still the aspiration of prophecy, but he is kindly, honest, and leads a simple life; he is truly the Purohita, the well-wisher of the village, as his name implies.

To the family there are many inseparable adjuncts. I have spoken of the poor relations. I think a picture of our family life would be incomplete without the household servants. A female servant is known as the *jhi*, or daughter in Bengal—she is like the daughter of the house; she calls the master and the mistress, father and mother, and the young men and women of the family brothers and sisters. She participates in the life of the family; she goes to the holy places along with her mistress, for she could not afford to go alone, and generally she spends her life with the family of her adoption; her children are looked after by the family. The treatment of men servants is very similar. These servants, men and women, are generally people of the humbler castes, but a sense of personal attachment grows up between them and the members of the family, and as they get on in years they are affectionately addressed by the younger members as elder brothers, uncles, aunts, etc. It is curious how, in Hindu life, we strike up a working relationship between the humbler and the higher classes and, though often separated by caste, address each other affectionately as near relations.

In a well-to-do house there is always a resident teacher, who instructs the children of the family as well as other boys of the village; there is no expensive school building, but room is found in some verandah or shed in the courtyard for the children and their teacher, and in summer under the shade of a tree, and into this school low-caste boys are freely admitted. Mr. Adams, who was employed by the East India Company in the early years of the nineteenth century to inquire into the system of indigenous schools, reported that in these schools not only was there a very considerable number of low-caste boys, but sometimes the teachers also belonged to the lower castes. Th indigenous schools were not of a very high order, but they supplied an agency of instruction for the masses which was probably not available in many other countries in those days. It is needless to remind you that, apart from these schools, there were great seats of learning, which were maintained by grants and gifts from the wealthier members of the community.

With Hindu life is bound up its traditional duty of hospitality. It is the duty of a householder to offer a meal to any stranger who may come before midday and ask for one. The mistress of the house does not sit down to her meals until every member is fed, and, as sometimes her food is all that is left, she does not take her meal until well after midday lest a hungry stranger should come and claim one. You thus see that the position of the mistress, though one of great authority, is also of considerable responsibility; she has the upbringing of the children, boys and girls; their religious instruction, the care of their material welfare; it is she who arranges their weddings and often determines their future career. Her rule is autocratic but based on love and understanding. In our country a mother-in-law is not an object of terror. When the son marries he does not set up a separate home, but brings his wife, when she is old enough to undertake the responsibilities of married life, to the paternal roof where his mother takes charge of the newly married bride and gradually affiliates her to the life of her new home. It is worthy of note that a motherless young man finds it difficult to get a bride from a well-to-do family, for no man is willing to give his daughter in marriage to a youth who has no mother to take care of the young wife. From the mistress of the house I come to the younger women: the daughter enjoys great liberty and is a chartered favourite, for she leaves you soon after marriage, and the daughter-in-law is made much of; the new home must be made sweet to her, so that she may not feel the change, and is she not to be the mother of your grandchildren, sweeter to you in your declining years than ever your own children were when you were younger? Life at home is not so dull to the young women as you may imagine; there is plenty of innocent fun and amusement; when the husband of a newly married daughter visits the home of his wife, the wife's girl friends, her sisters and cousins, are all aglow with excitement, and the poor newcomer has to submit to many practical jokes. Do not think that because our women do not go about they do not dress well. In well-to-do families they wear very expensive silks and muslins, light as gossamer and beautiful as a dream. You may well ask for whom should they dress? Well, they dress for their husbands; the Hindu wife does not care what others may think of her so long as she is acceptable in the eyes of her husband. After

all dress is an expression of beauty, and the sense of the beautiful is inherent in all women.

One hears a great deal of the Hindu woman's love of ornaments; you are told of the large absorption of the precious metals in India. To the Hindu woman, her ornaments are her insurance against rainy days. Banks and insurance companies are unheard of names in India. No husband, no son, however dire may be the necessity, will touch the ornaments of the women folk, but when the wage-earner dies and distress comes, and fatherless children have to be maintained and educated, and unmarried girls have to be married, these ornaments find their way, unknown to the men, to the village money-lenders or the village goldsmith, and the family carries on its life on the once cherished possessions of its womenkind. In all countries, in yours as well as in mine, women have set the example of ungrudging and silent devotion—it is the most precious endowment of humanity.

The younger women of the house, in their own way, assist in the maintenance of the household, in the preparation of food, in keeping the house clean and tidy, in the daily worship and in the performance of religious and social ceremonies, which are very numerous. In the afternoon, after the mid-day siesta, they gather together with the older women, when one of our great epics is read by one of them and listened to by all; these stories are illustrated by the older ladies by references nearer and more personal to the life of some past female ancestor or some great lady whom they knew. These stories are the storehouse of our spiritual life. They tell you how in a remote age, in the presence of the gods who were watching from above and the conquering army of her husband, Sita entered the fire to prove her innocence, and not even the ornaments of flowers she was wearing were singed; how Savitri in the olden days overcame the god of death himself by the great purity of her character, and brought back her dead husband to life; how Draupadi animated the drooping spirit of her husband, the King of the Pandavas, whose capital was Indraprastha, the site of modern Delhi, when he was in exile and his fortunes at their lowest ebb; they tell of women's love, of women's sacrifice and devotion; they tell of men, of their strength and their courage and their virtue; and they have passed as golden threads into the texture of our life, imparting to it its strength and beauty.

Of the Hindu wife I dare not speak, for who can sound the depth of her love and devotion? Custom, tradition, religion, have all combined to make her the crowning blossom of Hindu life; to the Hindu husband she is not merely the wife, she is the emblem of prosperity, she is not only his half, but heart of his heart and soul of his soul, and she is more, for she is his redeemer; weak and erring as man usually is, the merits of his wife assure him salvation, for she is his partner for all time, and God will not punish the good for the guilty, but the guilty will be saved so that the good may not suffer.

There are many more things of which I could speak, but time is pressing and your patience must be exhausted. I should like, however, to say something as to how Hindus take their pleasures and amusements. In times of festivals there is usually some musical performance in the house of a well-to-do citizen, when the life of some divine incarnation or mythical hero is represented in action and in song accompanied by instrumental music. The whole countryside come to the performance, and generally spend the whole night there. There are no letters of invitation or cards of admission; all are expected to attend and all are welcome. High and low sit down together on some carpet, or on the bare floor when there is no more room on the carpet. It is interesting to watch the audience. Sometimes you see them laughing at some humorous episode, sometimes weeping at the recital of a tragic event, and sometimes when the story is of great faith and devotion—as of Prahlada, who cheerfully submits to be cast into the flames rather than give up his faith—you see the whole audience deeply stirred, tense with devotional fervour; you feel the flapping wings of the Holy Spirit, and when the story reaches its climax, as when, for instance, Prahlada is saved, the assembled crowd gives a shout and cries out the name of God.

Then we have got the street musicians, who go about with a violin or a single-stringed instrument, called the *ektara;* they are not the organ-grinders of European cities, against whom we see notices put up here and there. There is no prohibition against these musicians going anywhere; they come to our houses before the breaking of the dawn, and, standing outside the door, sing the morning song, calling upon the earth to throw off its mantle of darkness, its unconsciousness of sleep, and greet the rising sun. He is an itinerant philosopher, this street musician of ours, for his songs are the compositions of great men inspired with living faith, and are full of the imagery of village life;

one of his songs is a great favourite with us in Bengal—

Like the oilman's bullock with the bandaged eye,
Round and round the wheel we go, but know not why.

This spirit, this belief that the external world is but a delusion is deep-seated in the Hindu mind, and high and low all cherish it; it is this which leads our men and women, when they have lived their life of the world, to retire for meditation, for communion with the Supreme Soul, which is the real essence of the Universe; it would be a mistake, however, to think of the Hindus as lost in contemplation, a mistake into which some Western observers have fallen, and which is probably the inspiring source of those beautiful lines so often quoted:—

The East bow'd low before the blast
In patient, deep disdain;
She let the legions thunder past,
And plunged in thought again.

But just as we realise that the external world is not of the essence, we also realise that activity is the foundation of faith and therefore of salvation, only our activities must not be founded upon selfish aims; it was said in the "Gita," a book of high value to us Hindus, that "work is your field and not the fruits thereof," and because we mortals cannot extricate ourselves from the coils of self there is in the Hindu mind always the longing to leave the activities of life when the time comes. And much depends on this limitation of time. For abnegation of the world is not countenanced before worldly duties have been discharged. Our great poet Kalidasa, speaking of a mighty race of kings, says of them that they devoted their boyhood to study, their youth to worldly duties, and their age to asceticism. The householder is regarded with greater favour than a *sanyasi* or ascetic.

Now, much as I should like to speak of other elements in our life, of our marriages, our festivities, and festivals and our funerals, and of our social system, my time and your patience have their limits, and I must close; but before I do so, I may answer by anticipation the question that may be suggesting itself to some of you, Does Hinduism satisfy the demands of modern enlightenment about religion and life? The same question might be asked of other religions and other systems, but I shall attempt to give a brief reply. In our ancient Scriptures are to be found the highest expression of human aspiration towards the divine. Some of the Vedic hymns, the teachings of the Upanishads, cannot be excelled; these have remained for many centuries, the exclusive possession of the select and the initiated; their great truths were illustrated in the Puranic stories of later times, which were accessible to all. Hinduism had to include in its folds many lower types of civilisation and beliefs, just as even now Christianity in Southern India recognises caste, and in Europe, class divisions; but the select knew the path and also knew that the path might be approached in various ways. When modern thoughts first invaded India early in the last century the higher knowledge was very much confined, and men began to rebel against forms which had become meaningless and often mischievous, and there was great commotion. It seemed as if Hinduism would break at last, but a great Brahmin in Bengal, deeply versed in the religious and philosophic lore of the Hindus, and also deeply read in the Semitic systems of faith, broke the seal which ignorance, superstition, pride and folly had placed upon the sacred Scriptures, and laid them bare to the wondering gaze of the rebellious intelligensia. Others have followed Rammohan Roy-Dayananda Saraswati of the Arya Samaj, Keshab Chunder Sen of the Brahma Samaj, Vivekananda of the Ramkrishna Mission. Their preachings have made the dry bones of the valley instinct with new life; forms have lost their deadness and worship its earthiness; abuses are freely recognised, which is preliminary to their removal, and with the inherited catholicity of their mental attitude the intellectuals find in their own system all that they want, and all that is wanted for the masses; for Hinduism provides, what other religions do not often do, an evolutionary process moving from stage to stage. Our forward thinkers are trying to expedite this process; we see social activities on all sides, a new awakening before a brighter dawn.

I am fully conscious that I have drawn a very incomplete and imperfect picture of Hindu life, but with the time at my disposal I could do no more. I do not know whether the aspect I have chosen will interest you, but it is an aspect not fully realised by outside observers, who see more of the form than of the spirit. I have tried to present this aspect to you from the Hindu point of view. You may not like to look at the picture from where I stand, and you may prefer your own position. So be it. I have no quarrel with you, only you may miss the soul of the picture you are looking at,

for, mind you, pictures have souls, as well as men and women.

I must now conclude. If I have succeeded in any degree in placing before you an impression of the subtle charm of Hindu life, which age has not dimmed, if in any degree I have succeeded in showing why the flowing tide of time has not unloosened the holds of its roots on the hearts of our people, I shall consider my task well done. If not, I do not despair, for I look forward on your part to a greater knowledge of my country and of our people, brought so near to you by the common sufferings of recent times, knowledge founded not on ideals of domination or superiority, whether of the missionary or the layman, but knowledge founded on ideals of equality and comradeship; and with better knowledge will come truer appreciation.

DISCUSSION.

THE CHAIRMAN (Lord Crewe) said that he thought Mr. Basu was fully justified in painting his picture in pleasant colours, taking the Hindu family as it ought to be, and as it very often was, rather than dwelling on exceptions which might appear to darken the picture. The description he had given was one which no Englishman, however sympathetic and well-informed he might be on the subject, could have presented from the same standpoint. There had been in the past, and still were, among Englishmen in India many men of profound sympathy and of no little knowledge of Indian life—such men as James Forbes—one hundred years ago or more, whose massive book, "Oriental Memoirs," rested on the shelves of many old English libraries, but perhaps was not read as often as it ought to be—and Samuel Macpherson, also an official of past days, who obtained an extraordinary inner knowledge of some of the wilder tribes of India. In more recent days there were such men as Sir William Hunter, whose work on Bengal had probably been read by many of those present, and Sir Alfred Lyall, one of the finest minds of the last generation. All those men could have written and spoken of the Hindu family with the utmost sympathy, but not with the inner knowledge that Mr. Basu possessed. Mr. Basu had also made some profoundly interesting observations on the Hindu faith. India was an intensely spiritual country; there was a conviction there of the unreality of mundane things such as existed, perhaps, nowhere in Europe, although, as Mr. Basu pointed out, that need not of itself make a man unpractical or unfitted to carry on the ordinary business of life. He did not know whether English people could claim in any way to cross the barrier that existed in that respect between India and the West. In the course of a conversation he had some ten or twelve years ago with a distinguished German public man, who knew this country well, the latter said he believed England was the only country in Europe that could be called, in a strict sense, religious. He (the Chairman) asked him what he thought about Germany, and whether he would not claim a religious character for the German people. The reply was that, although there were many religious minds amongst the German people, yet the national temper and bias were not religious. If it was true that English people were ahead of other European countries in that respect, that fact might bring us into somewhat closer concert with the Indian mind than would otherwise be possible. He hoped that might be so, because it was unquestionably to a closer knowledge of the Indian mind that we must look for progress in reforms throughout India, as was realised by many thoughtful people amongst the English officials in that country.

MR. G. K. DEVADHAR (editor of the *Dnyanprakash*, Poona) said the paper had enabled those present to understand something of the richness of faith, the simplicity of life, and, what he might call, the sublimity of part of the life of the Indian people. The basis of that life was self-surrender or self-abnegation. Religion and philosophy were so interwoven in the social and family relationships of India that it was a matter of great complexity to understand the way in which the Hindu family institution really worked, but it was a study which was very interesting to those who wanted to go deeper into the psychology of the human mind and human institutions. Many of those present might wonder how far the system of life described by the author, which seemed very poetic but which was more or less true of the whole of India, was going to stand the onslaught of so-called modern civilisation. The present time was one of many interchanges between different nations—not only interchange of commercial commodities but interchange of thought, and the question was how far Hindu life was going to be affected by that. Personally he had a robust faith in the element of stability in Hindu faith and Hindu civilisation, and its power to withstand the onslaught of Western civilisation. Students of Indian history would remember that Hindu civilisation had often been brought into contact with different systems of life, of philosophy and of civilisation, but it had not surrendered its individuality, although it had assimilated to a large extent the points that were worth adopting and absorbing from other lands. He believed that the contact of the East and the West was bound to have very beneficial and helpful results to both. He did not wish to idealise the life of the modern Hindu. It lacked at present some of the qualities which it ought to possess if it was to stand the test of the present day. The East needed a little of the energy and the organising capacity of the West, and the West needed the noble passivity and to some extent the peace of mind of the East. He believed that if India, without losing its individuality and the spirit of

sacrifice which more or less lay at the basis of its philosophy and religion, would absorb or imitate some of the noble and vital qualities of Western civilisation, such as energy, organising capacity and those qualities affecting the practical side of life, the Hindu civilisation would emerge brighter and nobler, and with an influence which it would cast upon the life of the rest of the world. In conclusion, he might say that he supported most of the sentiments expressed by the author.

MR. H. P. GHOSE (editor of the *Basumati*, Calcutta) said he took exception to the author describing his narrative as a story, for it was anything but a story—it was an album of carefully selected pictures of the Hindu life which the author even now led as the head of a huge family which was like a giant banyan-tree, giving shade and shelter with a tolerant catholicity unknown in any other country. In India the old order was changing, as it must under the new conditions, and he did not regret it, for change was significant of life. In the past Hinduism had never shut its doors against new ideas and new ideals. It was true that the peculiar position of India made its people develop a civilisation all their own, but other civilisations—Greek, Roman and Semitic—had left their impress upon it. Still the old structure remained to-day, and India lived—lived in her spirituality which had withstood the corrosive wear and tear of time, and which had survived those tidal waves of invasion and conquest which had swept over the country. The spirituality of India was the central point—the pivot of Hindu life, the inspiration of Hindu art and Hindu literature. Many of those present were familiar with Hindu literature. The songs of Rabindranath Tagore, which were so admired in England, were redolent of that exquisite aroma which breathed in the songs of Vidyapati and Chandidasa, Jayadeva and Ram Prasad, but they lacked that intensity of devotion which the latter songs possessed. Hindu literature was pre-eminently a religious literature, and Hindu art was nothing if not religious. The art ideal which passed through China to Japan and Corea, where it was still a living force, was developed in India to express a spiritual symbolism. In the temples of India should be sought and found the highest expression of art, and in the life of the people the expression of the spiritual ideal, which was so often lost sight of by the casual observer who did not dive deep into the social system of the country. The Hindu family had its joys and its sorrows, but above all, it had its importance as a training ground for patience, self-sacrifice and devotion to duty, and it taught a man that his work lay in the faithful discharge of his duties irrespective of the results that he might reap. The Hindu family might be called a republic, the head of which was the senior member, male or female, but when he or she felt the burden of years and found the younger members fit to take up the work, it was handed over to them. The great poet Kalidasa enjoined that when old the householder should devote his age to asceticism and prepare himself for the hereafter. That was the Hindu ideal which held good in the Hindu family, and that was the ideal that the Chinese had borrowed from India. Hindu family life had its grace, its charms, its pathos and its inimitable sweetness, but above all, it had its high spiritual ideal. A new age had dawned for India—the clash of the divergent civilisations was shaking the foundations of Indian society, but fortunately the dazzling glow of the materialistic civilisation, which made so many of the Indian people neglect their heritage and forget their past, had vanished. Men like Rammohan Roy and Dayanand Saraswati, Chandra Chatterjee and Vivekanada, had preached the truth that lay at the root of the Indian social system, and young India had listened to their preaching. The result to-day was that men like Mr. Basu understood that, while reforms were necessary, the people of India must hold fast to those principles which had secured the sanctity of ages, those customs which had been instrumental in the blossoming forth of Indian civilisation, and that faith in which generations of Indians had found solace. They could not dissever themselves from their historic and glorious past—Hindu men and women were wanted in the Hindu family, and not replicas of an alien type. He was sure Mr. Basu's paper would open the eyes of Europeans to the true character of Hindu life, and would open the eyes of young Indians to the heaven of peace that lay in their own social system.

VISCOUNT HALDANE, K.T., O.M., in proposing a vote of thanks to the author of the paper, said that the hearing of Indian Appeals in the Judicial Committee of the Privy Council had made him familiar with many of the institutions of which Mr. Basu spoke. He thought the unity of the Hindu family owed a great deal of its strength to the element of religion, and the room of the *Thakur*—the god to which the author had referred—was the very central point of the unity of the family, the various members of the family being all bound together in their religious duties. What was contained in the room of the god was not what English people, with their very materialistic way of looking at things, would call an image. It was a great deal more than an image. In the East there was a characteristic of thought which was also a characteristic of Ancient Greece—abstract concepts were not separated from images and presentations as they were in the West. Plato and Plotinus and Aristotle himself thought very largely in images when in the West we should have thought in abstract concepts, and in the East they thought still more in images, but yet the concept underlay the image and the two were not separate. Therefore, when reading Indian philosophy, one had always to remember to penetrate behind the veil of sense and detect in the product of the imagination the outcome of an abstract thought which was often of a

very profound kind. The family god, therefore, stood only as a symbol of a thought which was present in the minds of those who approached him; East and West were separate in that respect, but it was a separation in the mode of expressing deep concepts common to both. Mr. Basu had a thorough appreciation of the way in which English people looked at things, and he therefore knew how to illustrate his references to India in a manner which English people could understand; and also he was aware of all the broad considerations which after all were the common foundation of life in the East and in the West, because the identities were much more important than the differences. The identity would not be worth much if there were not the difference, but the difference was not such as to disturb the identity. He hoped the East and the West would always keep their various characteristics, because the strength of one side supplied that in which the other was weaker and the strength of the other lay in the possession of qualities peculiar to itself.

Lord Carmichael, G.C.S.I., G.C.I.E., K.C.M.G., in seconding the motion, said he had had great pleasure in listening to the paper and to the speeches that had been made. He did not think anything would prove more to the benefit of England and India than that the two countries should understand one another better. If the two nations were to have a sentiment binding them together they must not only know in what they resembled one another but they must also know where they differed.

Lieut.-Colonel F. S. Terry, in supporting the motion, thanked Mr. Basu for the way in which he had shown the unity of the family life in India, which had preserved so well for so many centuries the family emotions—paternal, filial, and fraternal. Through all the races of the world there was one point of unity which was most striking, namely, that the family emotions were potential, and therefore, in bringing those emotions and the care taken of them in India to the notice of the people of this country, Mr. Basu had performed a most valuable service.

The resolution was carried unanimously.

Mr. Bhupendranath Basu, in reply, said it was a great pleasure to him that his paper had been so much appreciated, and that pleasure was increased by the fact that on the present occasion the chair was occupied by a nobleman who had been intimately associated with the public life of India for many years. There was no Englishman more respected or more loved in India than Lord Crewe. He also wished to express his gratitude to Lord Haldane and Lord Carmichael. Apart from Lord Haldane's great services to India in hearing Indian Appeals as a member of the Judicial Committee of the Privy Council, his writings and his speeches had meant a great deal to Indians. Lord Carmichael had been Governor of the Province to which he himself belonged, Bengal, for five years, and during that time he made the people of the Province feel that he was one of themselves. Therefore the appreciation of the paper that had been expressed by both Lord Haldane and Lord Carmichael came to him as that of his personal friends and of men who were deeply imbued with the love of India. He also wished to express his pleasure at the fact that so many gentlemen who had done great services to India were present at the meeting.

A SUGAR FACTORY IN JAVA.

The sugar industry in Java has increased enormously during the last twenty years. Most of the machinery used is now made in Holland, but the Dutch manufacturers complain of foreign competition.

A description is given in *De Ingenieur* of a factory, situated in the interior of Java, which has recently been set to work. It will have an ultimate capacity of 3,000 tons of cane per day; at present it only deals with 1,500 tons per day, but extensions will be taken in hand as soon as additional land can be opened up. The management had hoped to get abundant local labour, as the district is densely populated and the people are poor, but they unanimously refused to work and labour had to be imported from other districts.

The specification calls for the sugar to be finished as raw or Muscovado Sugar No. 13, or as refined sugar No. 16. No attempt is made to recover by-products, and the evaporating plant is designed according to the "Pasma-Lautier" system.

The steam engines are of the single-cylinder non-condensing type, partly because the exhaust steam is utilised in evaporators and partly to economise the use of skilled labour, which is scarce. The buildings, power-house and pipe-lines are all designed for the full capacity of the works, but, so far, only one set of cane-mills, half the boilers, and a small number of auxiliary machines have been installed. The cane-mill is driven direct from the main engine, but all auxiliary machines, such as air pumps, injection pumps, hydraulic presses, etc., are driven by separate engines, connected to the main steam-pipe. This arrangement avoids belt drive and makes the working simpler and more reliable.

Another sugar factory has been started in Java during 1918, in which the machinery is, as far as possible, driven by electricity. When completed, it will have three turbo-generators for producing light and power. It has, nevertheless, three cane-mills and thirty-one large and small engines for driving auxiliaries, all steam driven.

The main building of the former factory covers 3·3 acres out of a total area built over of four acres. The buildings have steel framework and steel roofs, with outside walls of brickwork, the main building being 115 ft. wide and provided with a travelling crane. Modern machinery is installed throughout,

consisting of extra heavy cane-mills, a large number of vacuum pans, filter presses, centrifugal machines, pumping engines and all machinery necessary for treating cane juice and preparing the sugar. The final drying process takes place in inclined revolving drums, 6 ft. 6 in. in diameter and 33 ft. long, through which are passed counter currents of hot air.

The factory has an output of 12 tons of cane sugar per hour when working at full load, and the cost of production is well below the cost of producing beetroot sugar.

Three thousand light open railway trucks, each of 2½ tons capacity, are used for transporting the cane to the mills, where it is unloaded and handled entirely by machinery. Over sixty-seven miles of main and branch lines have been laid down on the estate, and light compound locomotives of 16 tons service weight draw trains weighing 120 tons up gradients of 1 in 100, and trains of 180 tons up gradients of 1 in 200.

The total quantity of sugar produced in Java amounts to 1½ million tons per annum, whereas the quantity produced in the whole of British India is about 2 million tons per annum.

AGRICULTURE IN ST. LUCIA.

An interesting *résumé* of the last annual report of the Agricultural Department of St. Lucia is given in the *West India Committee Circular*. The output of staple products in the island showed some falling off during the year ending March 31, 1918, but this was due to extraneous causes. Thus sugar was severely handicapped by the inability to obtain sulphate of ammonia, while cocoa suffered from shipping difficulties, though it is noted that the increased consumption of native cocoa locally contributed towards the reduction in exports by 2,859 cwt. The lime trade also experienced a setback, the exports expressed in barrels of fruit falling from 22,489 to 18,180 barrels, owing to lack of shipping opportunities. The coco-nut industry, on the other hand, showed gratifying expansion, the total number of nuts shipped amounting to 139,096, or more than double that of 1915—a small enough figure, it is true, but it is added that continued attention has been paid to the planting of larger areas in coco-nuts, and further expansion of this industry would therefore appear to be assured. There is also good progress in connection with the production of honey. Now that lime planting has become general, increased attention is being paid to bee-keeping by lime growers, as the value of bees in fertilising the flowers, thus producing larger crops of fruit, is becoming more generally recognised. The result is that the exports of honey show an increase of 17,389 lbs. during the last two years, the exports in 1917 reaching 46,724 lbs. Another flourishing minor industry in the island is that of tanning, the progress of which is reflected by a decrease of 6,570 in the exports of hides since 1915.

Several pages of the report are devoted to the visit of the entomologist of the Imperial Department of Agriculture, who investigated the black weevil banana borer and various other insect and fungus pests. Agricultural education also receives attention, and one of the most important parts of the report deals with the formation and work of the Economic Products Committee, which was formed to encourage agriculture and to consider what products were capable of profitable development, with a view of keeping present proprietors on the land and of preventing them from drifting into the towns or emigrating. It is recognised that the peasant grower, even more than the estate owner, is going to be the colony's chief asset, the coal trade being a subsidiary industry which cannot be depended upon to continue on its former scale. To meet the threatened food crisis, a Government granary was erected near the lime-juice factory, and active steps were taken to encourage the raising of ground provisions. Following the success of the Government lime-juice factory, which has now been accepted as a model for many factories elsewhere (inquiries having been received from such far-away colonies as Ceylon and Fiji regarding it), steps were taken to establish a coco-nut oil factory, where various products obtained from coco-nuts could be manufactured and a definite scheme was drawn up for the consideration of the Economic Products Committee.

The Agricultural Credit System is making headway in the island in spite of persistent efforts in some quarters to prevent peasants from becoming members, and of attempts in some instances to induce them to resign their membership. During the year four new societies were registered at Vieux Fort, Gros Islet, Anse-la-Raye and Castries, whose members brought the total of those of all registered societies in the island to 374.

FRENCH RAILWAYS REFRIGERATED WAGON SERVICE.

On the great French railways, according to an article by M. A. Barrier, chief of the Paris Camp Refrigeration Establishments, in *Le Froid*, there were 1,463,000 tons of perishable products carried in 1911, of which about 10,000 tons only were carried in refrigerated wagons, and the number of these did not exceed 360 in 1913 for the six railway systems, of which 149 were used for beer and 211 for foodstuffs. Enumerating a number of causes for this backward state of things—notably the prejudice of the public against refrigerated products—he notes, at the same time, a more favourable tendency in 1912-13. But it required the war to stimulate artificial refrigeration in France to the point reached to-day, which level, if maintained, should practically suffice for the country's needs in peace time.

The Eastern Railway Co. has no special wagons of its own, but 111 such wagons, practically all private-owned beer wagons, run on its lines. On the Southern (Midi) Railway not a single refrigerated or even insulated wagon runs. But

considerable numbers now circulate on the other large railways.

On the State Railway there are eighty-three insulated wagons—twenty-five used for dairy produce, thirty-three for frozen meat, and twenty-five are private for sundry uses; and recently two German and 100 English insulated wagons have been added under military instructions. On the Northern Railway there are seventy-seven refrigerated wagons belonging to the Société Française des Wagons Aérothermiques, nine of them being equipped to carry refrigerated meat. The Paris-Orleans Railway has a large number (750) of wagons for perishable products, but neither insulated nor cooled. But 201 of the company's wagons have been equipped as "war type" refrigerated wagons, with insulated walls, by the Supplies Department, and five more in private service are ice-cooled.

The Paris-Lyons and Mediterranean Co. had 3,182 double-walled wagons for early fruits, etc., but not insulated, of which the military requisitioned and equipped 550 as refrigeratod wagons for the duration of the war; but the ice tanks have already been removed from fifty of them as not being required in the French system. The 500 others may be cooled: By air circulation, 200 before starting; by brine circulation, 60 while travelling; or by a combination of both, 240. Those with brine circulation have a vertical ribbed pipe radiator battery at each end, separated off by a trellis partition. Besides these, the company has been instructed by the Supplies Department to insulate forty-four foreign wagons. The company controls a further ninety-five insulated and refrigerated wagons with ice tanks. Thirteen it owns and hires to the Enterprise Maritime and Commercial Co., which owns fifty, and the others are owned by various breweries. The P.L.M. has hired a wagon to the Association Française du Froid, which has been provided in the centre, lengthwise, with a complete cold-producing mechanism.

The Military Supplies Service had three German and one Austrian wagons fitted with a Fixary refrigerating machine, a condenser and brine refrigerator, driven by an Aster spirit motor, each to supply a number of wagons on the P.L.M. with brine circulation.

Twenty-five of the seventy-seven wagons on the Northern system are completely provided with machinery for producing cold by methyl-chloride, direct expansion; four are cooled by ice; while the others are simply well insulated.

OBITUARY.

Sir Charles Wentworth Dilke, Bt.—Sir Charles Wentworth Dilke, who died at Brighton on the 7th inst., was born in 1874. He was the son of the Right Hon. Sir Charles Wentworth Dilke, M.P., whom he succeeded as third baronet in 1911. He was educated at Rugby and Trinity Hall, Cambridge.

Although the late baronet was only elected a Fellow of the Society last year, the name had figured on the Society's lists, with a short break, since 1845, when Charles Wentworth Dilke, grandfather of the subject of this notice, became a member. Four years later *his* father, likewise Charles Wentworth Dilke, also joined; in 1857 the Right Hon. Sir Charles Wentworth Dilke, then a boy of thirteen, was elected, and in 1859 his younger brother, Ashton W. Dilke, joined the Society, so that at one time there were no fewer than four Dilkes on the lists.

The second Charles Wentworth Dilke took a deep interest in the Society's work. From 1846 to 1863 (with one short interval) he served on the Council, of which he was chairman in 1857–58. He was a member of the Society's Committee for promoting the Great Exhibition of 1851, and it was in recognition of his services in connection with this and the International Exhibition of 1862 that he was created a baronet.

The Right Hon. Sir Charles Dilke also served on the Council in 1869 and 1870, and on the Colonial Section Committee from 1896 till his death in 1911. He read two admirable papers before this Section, for each of which he received a silver medal; and he presided on several occasions at the Society's meetings.

GENERAL NOTES.

Iron Ore in India.—The discovery of very large deposits of iron ore to the south of Chakardharpur, within seventy-five miles of the Bengal-Nagpur Railway, was referred to by the chairman of that company, Mr. Robert Miller, at a meeting of the shareholders on December 5th. Several firms besides the Tata Iron and Steel Company have obtained concessions in these fields. One new steel and iron company has been floated during the past six months, and has selected a site for its works on the company's line. From the enormous deposits of first-class iron ore in sight, it would appear, Mr. Miller said, that the only thing which might prevent India becoming not only self-supporting in manufactured iron and steel, but also a large exporter of those materials, would be the difficulty of obtaining adequate supplies of coking coal.

Gas from Straw.—It is reported from Saskatoon that the Advisory Council of Scientific and Industrial Research is establishing a plant near the city for experiments to be made during the coming winter on the production of gas from straw. It is estimated that about 20 million tons of straw go to waste annually in the West; and it is stated that at a cost of $500 for the installation of a small plant, it is possible in an hour and a half to produce enough gas to last an ordinary farm-house three weeks.

REMOTE CONTROL FOR ELECTRICALLY-DRIVEN TRUCKS.—A description is given, in the *Electric Railway Journal*, of a third-rail, remote control system which permits stone-carrying cars to be operated in and about a quarry by an operator situated on a central tower. Small steam locomotives have hitherto been employed in most industrial plants requiring haulage of this nature, but the electrical system here described saves fuel and labour. In the Casarbis Stone Company's quarry (Kenneth, Ind.), it is desired to deliver from 5,000 to 6,000 tons of rock to the crusher per ten-hour day. Also it is required to move or extend the track easily. The equipment installed consists of twenty motor-driven dump cars, receiving energy for motive power and control from a third-rail system radiating from a central tower. Independent feeders connect the sections with the tower, from which one man can control all the cars. Motor controllers are located in banks to right and left of a bank of distributing switches, one switch for each feeder. This arrangement makes possible the control of cars on all track sections with a minimum number of motor controllers. The controllers actuate electro-magnetic contactors in the main circuit, and have three positions—forward, off, and reverse. When a lever is pushed forward, the rail section which is then controlled is connected through its feeder and a resistor in the tower to the 250 volt supply. As the lever is pushed further forward the resistance is cut out. With the lever pulled back, the same track section may be energised at 30 to 100 volts for braking and control purposes. One man operates twenty cars, which are served by three steam shovels, and yield service equal to that which would be rendered by seventy-five 10 cubic yard cars, twelve to sixteen 35-ton locomotives, and thirty men.

EGYPTIAN COTTON.—In the *Bulletin* of the Imperial Institute Mr. G. C. Dudgeon, Consulting Agriculturist to the Ministry of Agriculture in Egypt, discusses a question of great importance to Lancashire, viz., the maintenance of the quality of Egyptian cotton. It is well known that if any serious deterioration in the quality of Egyptian cotton occurred, it would inflict great damage on the British fine-cotton spinning industry. Mr. Dudgeon points out that Egyptian cotton has in recent years consisted of a number of varieties of cotton, each an improvement on its predecessor and each in its turn destined to deterioration, through crossing in the fields with inferior kinds. Owing to a series of fortunate accidents the quality of the cotton produced has, on the whole, improved, but he asserts that unless some system of protecting improved kinds is introduced there can be no guarantee that the present good quality of the output can be maintained. The principal action required is the isolation and issue of seed of the best kinds in a fairly pure state, that is free from seed of inferior varieties. The steps necessary to this end can only be taken by Government with the consent and active support of the Egyptian producers.

MEETINGS OF THE SOCIETY.

CANTOR LECTURE.

Monday afternoon, at 5 p.m.:—

JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." Three Lectures.

Syllabus.

LECTURE III. — DECEMBER 16. — Physical chemistry of the absorption of gases and dissolved substances—Solubility of gases in liquids as affected by pressure—Storage of acetylene—Charcoal as an absorbent of gases—Production of high vacua—Absorption of colouring matters from solution—Fuller's earth and charcoal—The dyeing process—Adsorption in soils.

Papers to be read after Christmas:—

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

FREDERICK WILLIAM KEEBLE, C.B.E., M.A., Sc.D., F.R.S. (Director of Horticulture, Food Production Department), "Food Production by Intensive Cultivation."

B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

A. F. KENDRICK, Department of Textiles, Victoria and Albert Museum, "English Carpets."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

LIEUT.-COLONEL H. G. LYONS, D.Sc., F.R.S., "Meteorology during and after the War."

W. L. HICHENS (Messrs. Cammell Laird & Co.), "The Wage Problem in Industry."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

J. F. CROWLEY, D.Sc., "The Use of Electricity in Agriculture in Germany."

SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

PROFESSOR JOHN CUNNINGHAM McLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

SANDFORD J. KILBY, "Indian Salt Manufacture."

H. KELWAY-BAMBER, M.V.O., "Coal and Mineral Traffic on the Indian Railways."

PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Exhaustion in India and its Influence on the Value of Crops."

BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., "Aerial Transport as affecting India."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

January 16, February 13, March 13, April 3, May 15.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

February 4, March 4, May 6.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m.:—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "Liquid Drops and Globules." Two Lectures.

January 1 and 8.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DECEMBER 16...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Cantor Lecture.) Professor James C. Philip, "Physical Chemistry and its bearing on the Chemical and Allied Industries." (Lecture III.)

British Academy, in the Theatre, Burlington-gardens, W., 5 p.m. Dr. A. Cowley, "The Hittites." (Lecture II.)

Alpine Club, 23, Saville-row, W., 8.30 p.m. Mr. W. P. Haskett-Smith, "Home Climbing."

Geographical Society, Kensington-gore, W., 5 p.m.

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 6.30 p.m. Mr. A. S. Jennings, "The Education of the Painter and Decorator."

TUESDAY, DECEMBER 17...Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. F. Mollwo Perkin, "The Production of Oil from Mineral Sources."

Sociological Society, at the ROYAL SOCIETY OF ARTS, John street, Adelphi, W.C., 8 p.m. Mr. J. A. Hobson, "The Misvaluation of Pacific Forces."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Dr. J. Brownlee, "Notes on the Biology of a Life Table."

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Discussion on following papers: 1. Mr. E. L. Leeming, "Road-Corrugation." 2. Mr. F. Wood, "Investigations in the Structure of Road-Surfaces." 3. Mr. T. B. Bower, "Notes on Road Construction and Maintenance."

Colonial Institute, Central Hall, Westminster, S.W., 4 p.m. Captain J. R. Kirk, "The New Zealand Soldier: His Outlook."

WEDNESDAY, DECEMBER 18...Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.45 p.m. Captain W. S. Farren, "Full Scale Aeroplane Experiments."

Meteorological Society, at the Institution of Civil Engineers, Great George-street, S.W., 7.30 p.m. 1. Captain C. J. P. Cave, "A Cloud Phenomenon." 2. Mr. C. E. P. Brooks, "Notes on a Meteorological Journal at Wei-Hai-Wei, kept by Commander A. E. House, R.N., 1910-1916." 3. Captain E. H. Chapman, "The Annual Symmetrical Variation of Certain Elements and a Note on the Choice of Seasons."

Geological Society, Burlington House, W., 5.30 p.m.

Microscopical Society, 20, Hanover-square, W., 8 p.m. Colonel A. Castellani, "Tropical Diseases met with in the Balkanic War Zone."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor W. R. Smith, "The Proposed Ministry of Health."

THURSDAY, DECEMBER 19...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture IV.)

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Summary of Progress in Photometry with special reference to War Problems.

Chemical Society, Burlington House, W., 8 p.m. Professor F. Soddy, "The Conception of the Chemical Element as enlarged by the Study of Radio-active Change."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, Westminster, S.W., 6 p.m. Mr. P. Hunter-Brown, "Carbon Brushes: Considered in Relation to the Design and Operation of Electrical Machinery."

British Academy, in the Theatre, Burlington-gardens, W., 5 p.m. Dr. A. Cowley, "The Hittites." (Lecture III.)

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. C. F. A. Voysey, "Æsthetic Design in Reinforced Concrete Buildings."

FRIDAY, DECEMBER 20..Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture V.)

Engineers, Junior Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.30 p.m. Presidential Address by Colonel R. E. B. Crompton.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—December 13, 1918.

No. 3448. DECEMBER 20, 1918. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON :
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,448. VOL. LXVII.

FRIDAY, DECEMBER 20, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Thursday, December 12th. Present:—

Sir William Duke, G.C.I.E., K.C.S.I. (Chairman of the Committee), in the chair; Sir Charles H. Armstrong; Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Sir M. M. Bhownaggree, K.C.I.E.; W. Coldstream; Sir Frederic W. R. Fryer, K.C.S.I.; Colonel A. Gleadowe-Newcomen, C.I.E., V.D.; Sir H. Evan M. James, K.C.I.E., C.S.I.; Major-General Beresford Lovett, C.B., C.S.I.; Sir Charles C. McLeod; Sir Frederick A. Robertson, K.B.E., LL.D.; N. C. Sen, O.B.E.; J. A. Voelcker, M.A., Ph.D., F.I.C.; and N. N. Wadia, C.I.E., with S. Digby, C.I.E (Secretary of the Section).

CANTOR LECTURE.

On Monday afternoon, December 16th, Professor James C. Philip, O.B.E., M.A., Ph.D., D.Sc., delivered the third and final lecture of his course on "Physical Chemistry and its Bearing on the Chemical and Allied Industries."

On the motion of the Chairman, the Hon. Richard Clere Parsons, a vote of thanks was accorded to Professor Philip for his interesting course.

The lectures will be published in the *Journal* during the Christmas recess.

JUVENILE LECTURES.

The usual short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, January 1st and 8th, at 3 p.m., by Mr. Charles R. Darling, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, on "Liquid Drops and Globules."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

THIRD ORDINARY MEETING.

Wednesday afternoon, December 4th, 1918; Stanley Davenport Adshead, M.A., F.R.I.B.A., Professor of Town Planning, University of London, in the chair.

The paper read was—

HOUSING AFTER THE WAR.

By Benjamin Seebohm Rowntree.

Before we can usefully discuss the subject of Housing after the War, we must consider the condition of housing in this country in 1914, and see how the war has affected it.

In 1914, the supply of houses was deficient both in quantity and quality. After very careful investigation, covering over 2,700 parishes, the Land Enquiry Committee estimated that, quite apart from the fact that many unsuitable houses were being occupied, there was a shortage of houses in the rural districts of England and Wales which probably amounted to at least 120,000. The same Committee, after investigating housing conditions in a number of towns, concluded that there was a shortage of houses in half the towns of England, and

in not a few cases an actual house famine. Speaking as a member of the Committee, I can testify to the impartial spirit in which the inquiries into housing were undertaken, and to the moderation of the estimates.

As for the quality of the houses, we may broadly divide them into three classes. In the lowest grade we must put the houses which, when crowded together, constitute slums. Many of them are individually unfit for human habitation; some are unfit by reason of their congestion in sunless courts or streets; the majority are unfit in both respects. They are the happy hunting ground of phthisis and other maladies, and it is almost impossible for their occupants to be healthy. As to the number of such occupants, we have no exact statistics. But it is probable that between 5 and 10 per cent. of the working-class population live in slums or slum houses.

In the grade above are the ordinary long monotonous rows of working-class houses, not individually insanitary, and not so crowded as to exclude air and sunlight, but built thirty, forty, and even fifty to the acre, with no gardens or greenery of any kind, each house and each street an almost exact replica of its neighbour, and all of them unlovely. The term unlovely, however, does not in the least express the blank, hideous, mean respectability of such streets. The internal arrangements of the houses vary, but they open direct from a narrow road, there is usually a small living room, with a scullery behind in which the bulk of the work is done, and behind that outbuildings containing coal-house, and water-closet. From the scullery window there is a view—calculated to cheer the housewife—of a small yard, and beyond it the back of the next street. More than half of these houses have only two bedrooms, and a bath is a rare exception. The great majority of working people live in such houses.

Next are the houses occupied by the better class artisans. We are all familiar with the type. There is a little front garden, covering a few square yards, usually separated from the road by a low railing. There is a parlour with a living room behind, and behind this a scullery and the usual offices. These houses have three bedrooms, and sometimes four, and their back-yards are somewhat larger than the backyards previously mentioned. Less than a quarter of the working classes live in them.

At the top of the scale there are an insignificant number of houses laid out on garden suburb lines. These are usually built about twelve to the acre, and each house has a garden. They are artistic in appearance, and care has been devoted both to their design and the lay-out of the building estates.

I do not want to burden this paper with a mass of statistics, but before we can realise what housing conditions were in 1914 we must also remember that 9 per cent. of the population were living under overcrowded conditions, that is, more than two persons to a room. This means that there were more than eight persons in a four-roomed house, or a house with two bedrooms. A house with only two bedrooms and only eight people was not, technically speaking, overcrowded.

According to the Census of 1911, out of a total of about eight million tenements in England and Wales, over one half contained four rooms or less, over one quarter contained three rooms or less, while nearly a million contained only one or two rooms.

Such, then, were conditions before the war. I think we shall all agree that they fully justified the statement made by the Prime Minister in Manchester that "The housing problem in this country is the most urgent that awaits solution."

The reason for the shortage, speaking in general terms, was that practically all the houses were provided by speculating builders, who could only continue to build if they could find a ready sale. The great bulk of the houses were bought by small investors who borrowed two-thirds of the purchase price on mortgage. But the owning of house property was growing less and less attractive as an investment. The cost of building had been rising for some years, and so had the burden of rates; but rents had not risen in proportion. At the same time the small investors were becoming more and more accustomed to investing in other securities, on which the rate of interest was steadily rising. Thus, speculating builders found it increasingly difficult to sell working-class houses, and they gave up building them. I know that it is generally supposed that the reduction in the supply of houses was due almost entirely to the Finance Act. This view, however, is not substantiated by the evidence. Certainly the agitation against the Act gave a temporary check to building; but it contains no clause which renders the ownership of cottage property undesirable, apart from the effect of the Lumsden judgment, which would have been rectified had the war not intervened. Close and impartial investigation of the facts has satisfied me that speculating builders built fewer cottages chiefly

because rents had not risen in proportion to the cost of building, while other opportunities for investing small sums at lucrative rates were opening out on every hand. But for the war rents would eventually have risen, and the speculating builder would once again have built working-class houses in larger quantities. But workers are very slow to agree to increased rents, and they will only do so when the shortage of houses becomes so acute as to render it impossible to do anything else. There is overwhelming evidence that, quite apart from the Finance Act, the serious shortage of houses would not have been made good if we had continued to trust to the law of supply and demand. Far-reaching legislative action was necessary to put the housing of this country on a satisfactory basis.

But conditions are far worse to-day than they were in 1914. Taking the ten years, 1904 to 1914, the average number of houses built annually, and let at a rental of less than £20, was about 75,000, but since the beginning of 1915 only about 50,000 houses have been built. Thus, on the assumption that a normal number would have been built but for the war, the additional shortage due to this cessation of building amounts to 250,000 at the present time. In other words, allowing for the normal output of next year, if we build 325,000 houses by the end of 1919 we shall just make good the additional shortage of houses created by the war.

The very serious pre-war shortage will still remain. It may, of course, be urged that we shall not require so many houses on account of the large number of casualties. This, however, is not the case, for three reasons—(1) The marriage rate during the war has been high; (2) many of the men who have been killed were married, and their families will, of course, continue to need houses; and (3) there has been practically no emigration since the war broke out. Probably these three factors will nearly or wholly cancel out any decrease in the demand for houses that is due to casualties.

Now, we cannot tolerate the conditions that I have just described in the new world that we wish to create. We cannot afford to continue to allow 5 or 10 per cent. of the working people to live in unhealthy houses. We cannot expect, again quoting the Prime Minister, "to raise an A1. population in C3. homes." Every communicable disease spreads like wildfire in overcrowded tenements, and saps the vitality of the nation. Moreover, are we to allow the men, who have for years been suffering the terrible hardships of war, to come back to find themselves houseless and homeless, without even the prospect of anything better in the immediate future?

But there are other reasons why a housing programme on an unprecedented scale should be carried out during 1919. It is notorious that in addition to the positive shortage of houses in rural districts, a large proportion of those which exist are really unfit for habitation. Their occupants have been willing to put up with them because they have never known anything better. But the agricultural workers who joined the colours have been thoroughly shaken out of their ruts, and before they return to their old work they will ask three questions—What are my wages to be? What prospects of advancement have I? And what kind of a house will be provided for me?

If they are not satisfied with the replies, many of them will either seek work in towns or emigrate. We cannot hope to retain them on the land, unless we immediately set about improving their housing conditions. Moreover, two million acres of grass land have been ploughed up, and far more labour will be needed to cultivate it than was previously employed. From every point of view there is the most urgent need for prompt action, on lines that are generous and far reaching. We must do more in rural districts than make good the shortage created by the cessation of building during the war. The men will not expect miracles to be worked on their behalf. They will wait a reasonable time for houses, if they see that the country is in earnest in its efforts to meet their needs. But they will not be put off with vague promises.

There is another reason for a bold and extensive housing programme for 1919. The dislocation of industry due to demobilisation will inevitably lead to a period of unemployment, until the factories which have been engaged on the production of war material are once more dealing with the requirements of peace, and until the supply of raw materials imported from abroad is sufficient to enable industry to get into its normal stride. The building of a large number of houses would provide employment for hundreds of thousands of men, who would otherwise be out of work. This is a matter of real moment. I recognise that it is useless to ask for the impossible. But I believe that it will be perfectly possible—granted energy and determination—to build

325,000 houses in 1919, and this, roughly, would employ 400,000 men for a year, in addition to those employed in the making of furniture, fittings, etc.

In this proposal I do not overlook the difficulty of obtaining building materials. There is a shortage of timber and of bricks. As regards the former, we have learned, during the last year or two, that thoroughly satisfactory cottages can be made with very little woodwork in them. As regards bricks, they are not the only material out of which good cottages can be built. Concrete blocks and other materials will yield excellent results.

If we build 325,000 houses in 1919 we shall approximately make good the additional shortage due to the war. In 1920 we must set to work to reduce the pre-war shortage, and at the same time to abolish slums.

But what type of houses must we build? The defects of working-class housing at present are broadly as follows :—

Houses are crowded together, far too many on the acre, and therefore they have no gardens. There is scarcely any attempt to lay them out scientifically, with due regard to the practices of good town-planning; the proportion of houses with three bedrooms or more is much too small; generally speaking they have no bathrooms, and from an artistic point of view their appearance is utterly depressing. How far can we hope to overcome all these defects in the future? With regard to the first point, the President of the Local Government Board, in his circular to the Local Authorities of March 18th, 1918, stated that, save in exceptional circumstances, the houses should be built not more than twelve to the acre in towns, and eight to the acre in the country. These are the limitations adopted in good garden suburb schemes, and only the conservative sentiment that is so deeply rooted in more than one political party can prevent us from making them practically universal. Of course many arguments against such a policy have been brought forward. First, it is often urged that the adoption of the above limitations would involve an enormous increase in outlay upon roads. It seems at first sight mathematically certain that the cost of roads and sewers per house must be much greater when houses are built twelve to the acre than when they are built on a very narrow frontage, and crowded thirty or forty to the acre. But closer analysis of the actual facts disposes of this theory. If houses are built in long rows, in gridiron fashion, money is wasted on roads in two ways. First, there is a great waste of frontage in all cross-roads which run only along the sides of the houses and yards, and secondly, back roads are practically inevitable. But with proper planning it is possible to build houses twelve to the acre with no waste of frontage and without back roads. Moreover, side roads and cul-de-sacs may be much lighter in construction, and consequently cheaper to make, than roads in crowded areas, which have to bear far heavier traffic. Again, except in the main roads, the roadway itself may be comparatively narrow, adequate distances between the houses being secured, partly by grass verges, which are inexpensive, and partly by front gardens to the houses. Experience has shown that if we take advantage of methods of this kind, the cost of roads and sewers per house need be hardly any higher for houses built twelve, than for houses built thirty or forty to the acre.

Other critics of open development say that it would involve a very great expansion in the size of our towns, and correspondingly increase the distance which many workers must travel to and from their occupations. In this connection, however, it must be borne in mind that the area of a circle increases, not in proportion to the distance from the centre to the circumference, but in proportion to the square of that distance, and consequently if towns are so arranged that those living in the suburbs can get quickly to the centre, the open planning should cause no serious inconvenience.

Another criticism which is frequently urged is that open development would involve very heavy rents in districts where land is dear. But at present the price which builders are willing to pay for land is based on the assumption that they can crowd thirty or forty houses on every acre. If they were only permitted to build twelve houses to the acre, they would refuse to pay so much, since they would know that if they did they could not let the houses at a remunerative figure. Sooner than pay a very high rent the workman would go a little further out, where land was cheaper. Therefore if the number of houses per acre is limited, say to twelve, only land offered at a reasonable figure will find a market for cottage building. In large towns, doubtless, this will mean that cottages cannot be built near the centre of the town, where land may be sold at a high price for the erection of shops or factories. But, surely, it is not a disadvantage to live in the

suburbs! The wealthier citizens of our towns have done so for a long time, as a matter of choice, and the health and welfare of the workers will benefit incalculably when they too enjoy ampler space and more sunshine and fresh air. Undoubtedly adequate transit facilities must be provided where they do not already exist, but these are a necessary condition of a modern civilised community. I believe that in the near future we shall see great developments in this direction. Workers should be enabled not merely to live in the outer fringe of a town, but outside it altogether. The economic effects of the existence of cheap and rapid transit are important and far-reaching, and may be studied in Belgium. That country, before the war, had developed its transit system to a greater degree than any other country in the world. For every hundred square miles of her territory Belgium had thirty miles of main railway, and twenty-two miles of light railway, as compared with twenty-two and 0·3 miles respectively in Great Britain, and her workmen's fares were extraordinarily low. Consequently a large proportion of her population lived in the country, although working in the towns—a mode of life which not only reacted most favourably on the health of the workers, but added to their security. A town workman who lived in the country, and had a good sized plot of land, did not walk the streets aimlessly when his usual occupation failed him, but spent his time in his garden, or, perhaps, found work with a neighbouring farmer. The Brussels bricklayer never thought of coming into the town at all during frosty weather, and the Antwerp docker would come down to the docks early in the morning, and if there was no work he would return to his own "potato patch." The advantages of having two strings to his bow were quite inestimable.

There is another point which must be carefully safeguarded in the preparation of our new housing schemes. It is that all building estates must be laid out in accordance with the best principles of estate development. We have seen already the importance of effecting economy in the cost of roads and sewers. But it is also important, so far as possible, to consider the appearance of the house; and it is quite imperative so to place it as to secure the maximum of sunlight in the living rooms. At present, houses are arranged almost without regard to their aspect. Precisely the same plan is adopted for a house facing south as for one facing north, and consequently, in one or the other, the living rooms receive hardly any sunlight. We can all realise what a serious defect this is in such a climate as our own. Town-planning is a comparatively recent science, and all building estates in future should be laid out only by those who have mastered its principles.

When we have secured the proper lay-out of the estate, we must consider the planning of the individual houses. We may deal in a few words with their external appearance. Much more consideration should be paid to this in the future. Hitherto the plans of working-class houses have usually been prepared by builders without the aid of an architect who is also an artist, and with the dreary results of this policy we are all far too familiar. It must be pursued no longer. It is just as cheap, or almost as cheap, to build a beautiful house as an ugly one, for beauty of design is not a matter of costly ornament. Moreover, much may be done in the arrangement of blocks of buildings. Long unbroken lines can be avoided by setting some of the buildings back, and by building some of the houses in quadrangles, with gardens in the centre. It is very poor economy, when erecting a number of houses, to save a few pounds by dispensing with the services of a good architect.

As for the interior of the house, there should be sufficient rooms, and they should be arranged with a view to the convenience of the housewife. With few exceptions, every house should have at least three bedrooms. Even if there are only two children three bedrooms will be required as soon as they grow up, if they are of different sexes. There should be a bath in each house. Hitherto it has been a common practice to place the bath in the scullery, but this method has obvious disadvantages and should be avoided if possible. Where a separate bathroom cannot be provided, arrangements should be made for screening off the bath in the scullery when it is in use. There is a difference of opinion as to the relative advantages of a large living room, and a smaller living room and a parlour, but most people seem definitely to prefer the latter arrangement, and I think that as a general rule a parlour should be provided. We are looking forward to a great extension of continuation education, and in every way adults will be encouraged to study. The success already achieved by the Workers' Educational Association is very striking, and there is no doubt that far more progress will be made in this direction. But it is impossible for an older child or an

adult to study in a living room, no matter how large, when other persons are playing or talking around him. A separate room is essential. Moreover, the standard of life among the working-classes is rising and it will continue to rise, and in planning the "Houses of the Great Peace," to quote the Labour Party's manifesto, we must not build for to-day only, but for the next century. To leave out of account economic and industrial development in planning our houses would be sheer folly. As a general rule, then, every house should have as a minimum three bedrooms, a bathroom, a parlour, a living room, and a scullery, all of them arranged with due reference to the convenience of the worker. Those responsible for preparing plans should take counsel with women who live in cottages, and who can tell from experience where the shoe pinches day by day.

And in my description I must not forget to mention the garden. When houses are built not more than twelve to the acre, each of them will have a good garden—an advantage which can hardly be over-estimated.

So much, then, for the kind of cottages which we must build and the way in which we must lay them out. We now come to two other very important questions. What will they cost, and who is to build them?

It is well within the mark to say that at present the cost of building is more than double what it was in 1914. It will certainly, however, drop within the next few years; and therefore, since houses last a long while, those which are built to-day will have to compete in the future with others built at a later date and at a much lower cost. This means that their capital value will depreciate rapidly. In these circumstances no one who can afford to wait, or who is building merely as an investment, will build during the period of abnormally high prices. We see, then, that although from the national standpoint it is absolutely essential that a very large number of houses should be erected next year, no such programme will be carried out without a heavy State subsidy. This is the answer to the question "Who is to build the houses?" In the past more than 95 per cent. of our working-class houses have been built by private enterprise, principally, as I have stated, by speculating builders. But it is in the highest degree improbable that Parliament will subsidise men who build for profit. Such a policy would involve serious and far-reaching difficulties. Yet, if the private builder is ruled out, his place must be taken by some form of public enterprise; and, doubtless, in the next two or three years the great bulk of the houses will be built by local authorities. This does not mean the ruin of the building trade, for practically all the authorities will build on contract. A certain number of houses will be erected by Public Utility Societies, that is, by societies registered under the Industrial and Provident Societies Act, 1893, the rules of which prohibit the payment of interest or dividend at a rate exceeding 5 per cent., and which cannot therefore be regarded as trading for profit in the ordinary sense. But though they will doubtless play a useful part in the working out of the building programme, their contribution will be very small compared with that of the local authorities.

Since, therefore, we cannot trust to the normal operation of the law of supply and demand to provide the houses, it will necessarily become the duty of the State to ensure that an adequate supply is provided, and this duty will fall on the Local Government Board. The task is certainly Herculean. It is to ensure the building, through agencies which have hitherto never built on an extensive scale, and some of which are apathetic, of four times the number of workmen's houses usually built in a year; the houses to be much better planned and laid out than in the past, and this to be accomplished at a time when materials are exceptionally difficult to obtain, and when labour is disorganised. If the task is to be accomplished satisfactorily, and within the time limit, it must be approached in the spirit of sheer determination which characterised the Ministry of Munitions when it organised the production of untold quantities of munitions of new type, and manufactured by firms previously quite unaccustomed to the work. There is not a day to be lost if the end in view is to be achieved. Good plans cannot be prepared in a moment, nor can suitable land be chosen in the twinkling of an eye. Fortunately we have at the head of the Local Government Board a man of great determination and organising ability. It is not for me to suggest what central organisation will be necessary to deal with the situation. But, obviously, in order to carry out this great enterprise, a Housing Department must be established at the Local Government Board that is quite exceptional both in the size of its staff and its administrative powers. This is no time for temporising or taking refuge in half measures. It will be necessary to make arrangements for securing an adequate

supply of building materials, for manufacturing standardised parts on an enormous scale, and for the distribution of materials where they are needed. In view of their shortage, control of prices for a time, at any rate, seems inevitable, and there must also be a system of priority certificates, so that the materials available shall first be used for purposes of national importance, such as the erection of cottages and additions to factories. Moreover, there will be urgent need of capable Housing Commissioners, each responsible for a district who will act as local agents of the Local Government Board, and settle on the spot the localities in which the 325,000 houses to be built in the first year are most urgently required. In addition to securing the actual erection of the houses, they should give every assistance to local authorities in the preparation of thoroughly satisfactory schemes.

Perhaps I may at this stage interpose a statement regarding the financial terms which the Government is offering to local authorities. Without going into detail these are, that three-quarters of the loss due to building at a time when prices are abnormally high instead of waiting until the post-war normal level of prices is reached, shall be borne by the State. The remaining quarter will be borne by the local authority, with a proviso that if the latter's share of the loss would involve a burden on the rates of more than a penny in the pound, the President of the Local Government Board is empowered to defray such additional cost, as well as the 75 per cent. which the State bears in every case. No definite promise to limit the burden on the rates to a penny in the pound has been made, but the President of the Local Government Board has said that he proposes to interpret his powers generously in this matter. The subsidy will only be granted if the plans submitted by the local authorities are satisfactory to the Local Government Board, which has stated that, save in exceptional circumstances, it will only give a subsidy when the number of houses is limited to twelve to the acre in towns and eight to the acre in rural districts. The whole scheme, moreover, must reach a certain standard of excellence.

Now I want to say a word as to the duty of the public in assisting the Government in the great task before it. For the first time the people of this country are able, through their elected representatives, to choose their own houses. It is of supreme importance that full advantage should be taken of this unique opportunity. In the past a private builder could put up any house, no matter how ugly or how ill-planned, and lay out his building estate as unwisely as he liked if only he complied with the minimum requirements of the local by-laws. Under such conditions it was very difficult to raise the standard of housing save by slow and gradual stages. But now, we have a chance of actually transforming it in a single year. Let us make the most of this chance! It may be urged that there is nothing for the public to do, because houses which do not come up to a certain standard will not qualify for the subsidy. But there is all the difference in the world between houses which are just good enough to scrape through the Local Government Board's test and ideal houses. It is for us all to see that the housing schemes submitted by our local authorities are not mediocre, but first-rate. Many local authorities are already thoroughly alive to the importance of the occasion, but I know for a fact that many others do not in the least appreciate it, and unless strong pressure is put on them by public opinion very inferior housing schemes will be prepared. In view of the huge magnitude of the undertaking it will not be possible for the Local Government Board to adopt a rigid attitude when deciding whether to subsidise a scheme or not. We may dimly realise what they are up against if we reflect that even if an inspector of housing schemes in the central office dealt with 100 house plans per day and worked 300 days a year, it would take him nearly eleven years to examine all the schemes. But, as a matter of fact, no one man could possibly check the plans of 100 houses in a day in an effective manner, and even if we have a very large central staff there is a danger that many schemes, falling far short of the ideal, will slip through, unless the work is unduly delayed. It is essential therefore to see that good schemes are prepared in the first instance.

What practical steps should be taken to secure this end? In the first place, we must create a strong current of public opinion with regard to the importance of improved housing conditions. We must make all progressive members of local authorities feel that they have behind them a public which is quite determined to insist upon the preparation of adequate and satisfactory schemes. I suggest that in every locality those who are eager for housing reform should organise an advisory committee to deal with the whole subject. Such a committee

would ascertain exactly what steps the local authority has already taken; whether it has considered the circular sent out by the Local Government Board on March 18th, 1918; what action has been based upon it; how many houses it proposes to build altogether, and how many per acre; what accommodation the new houses are to provide, whether the plans have been prepared, and are open for public inspection; and whether a building site has been acquired, or an option obtained on a piece of land. When the committee has obtained answers to the above questions, it should find out if the proposed action of the local authority is adequate, obtaining estimates from various people well acquainted with the subject, as to the actual shortage of houses. In different parts of the country housing experiments have been carried out with great success, as at Letchworth, Bournville, Hampstead, Port Sunlight, etc., and these should be studied. It would be a considerable advantage if some members of the committee could visit a garden suburb and see for themselves on the spot what well-planned and scientifically laid-out building estates are really like. Such a visit is of more educational value than a library of books. The next step should be to collect the best possible plans of cottages, and to compare them with the plans prepared by the local authority. If possible the committee should secure the help of an architect, or someone having expert knowledge of plans, and knowing how the cost of a well-designed cottage would compare with that of another which was not so well planned. This course is advisable, as otherwise the committee might advocate a type of cottage the cost of which was prohibitive.

If the local authorities are decidedly apathetic, or if the proposed scheme is inadequate, the committee should organise a town's meeting on a large scale, inviting all the progressive councillors to attend and getting a good speaker to outline the whole case. This meeting might arrange for a strong deputation to wait upon the council, which would urge them to initiate a bold housing policy at once, and promise to support them in doing so. All organised bodies such as the trades' council, the trade unions, political organisations, co-operative guilds, citizen leagues, adult schools and brotherhoods, and other religious societies, should be convinced of the vital importance of giving the workers homes that are worth calling homes; and they should be induced to support a public agitation to compel the council to acknowledge and to fulfil its due responsibilities. In large cities, the work connected with such a committee as I suggest might well occupy the whole time of an organiser. To be effective, public opinion must be created quickly. To stimulate it by vigorous action does not imply criticism of the work of the council. On the contrary, progressive members of local bodies will be the first to welcome the awakening of public interest in housing. Nothing is so discouraging to an enthusiastic councillor as the feeling that the man in the street cares nothing about the reforms which he is striving so eagerly to promote.

Before concluding this paper I must deal with the question of cottage rents. At present all house rents below a certain figure are prevented by law from rising above what they were in August, 1914, and, similarly, mortgagees who have lent money on the security of houses at such rentals are forbidden to charge an increased rate of interest. In consequence of this Act, although practically everything else which enters into the working-man's budget has risen in cost, he is paying no more for his house. But the market value of money has increased by 1 to 1½ per cent, and the cost of house repairs is more than twice as high as before the war, so the mortgagees who have lent money on working-class property, and the landlords of such property are much worse off than they were. One provision of the Increase of Rent and Mortgage Interest (War Restriction) Act was that it should expire six months after the war. But it is clear that, in view of the length of the war, and the greatly increased shortage of houses, its complete expiry in so short a period would lead to a sudden and in many districts, an unprecedented rise in rents, which might have very serious consequences.

A Committee is now sitting to consider the legislation embodied in the Act, and to make recommendations with regard to the removal of any difficulties which may arise in connection with it. This Committee has not yet issued its report, and it is uncertain what course the Government may take in connection with the matter. It would, however, seem probable that sooner or later the Act must be rescinded, and rents allowed to find their own level in the ordinary way. Clearly if landlords and mortgagees are to regain their pre-war position the rents obtained must cover the rise in the market price of money, and the additional cost of repairs, and this is pretty

certain to mean a substantial permanent increase.

But there is another factor which will have a very important bearing on rents in the future, namely, the increased cost of building. I have already stated that building costs twice as much as before the war. The cost will certainly fall, but no one can say how much. It would, however, be optimistic to assume that the post-war normal cost of building will be less than 25 per cent. higher than the pre-war cost. Thus, the commercial rent of a house built after the war will be 25 per cent. higher than the commercial rent of a similar house built before the war. It is unthinkable that such a difference between the rents of post-war and pre-war houses can be maintained in the open market. But unless it is bridged by some definite and well-considered policy, the rents of pre-war houses will tend, when the present restrictions are withdrawn, to reach the level of the rents of post-war houses. But if they do, their recipients will come into possession of an unearned increment amounting to some hundreds of millions of pounds. This would, I am confident, be strongly resented by working people. The only alternative is by some method to lower the rents at which post-war houses can be let. Personally, I only see two ways of doing this. One is to grant a permanent subsidy, a course so unsatisfactory that I think it need not be considered. The other is to adopt a method of differential rating, and I think we shall be driven to do this. If post-war houses were rated on the site value only, while we continued to rate pre-war houses on the value of the composite hereditament—that is, the value of the site plus the value of the buildings—the advantage secured by the post-war houses would go a very long way towards meeting the increased cost of building. It might suitably be provided that any increase in rates should be levied on land values. Thus if the rates in a town at the present time were 8*s*. in the pound, and new houses were built, the 8*s*. rate would be levied merely on the site value of the land on which they were erected. If the rates rose to 9*s*. old houses would continue to be rated at 8*s*. on the buildings, but the site on which they stood would be rated at 9*s*. The sites on which new houses are built would similarly, of course, be rated at 9*s*., but the houses themselves would continue to escape rating. All additions to old houses should be free from rates. The effect of this differential rating would be to give a great stimulus to building, and to encourage the private builder to begin operations much earlier than he would otherwise do. It would also facilitate the abolition of the slums. If slums were pulled down and new houses erected on the sites, these would be free from rates, only the site being rated. Further, it would give a stimulus to the erection of new shops and factories, which, unless something of the kind is done, will always be heavily handicapped by the higher cost of building when competing with shops and factories built before the war. It may be urged that to adopt this policy would increase the burden of rates on existing houses. But the only alternative which I can perceive is to let matters take their course. In that case, as we have seen, rents of existing houses will rise as soon as the present restrictions are removed, until they approximate to the rents of new houses. This would involve a much heavier burden on the occupants of the old houses than any slight addition which might arise from differential rating. Moreover, by levying a rate on site values, much land would be rated which now escapes rates, or which is very much under-rated, and the assessable value of the rating area would be correspondingly increased.

In looking to the future, we have to face two facts: (1) the rents of existing houses must rise to cover the increased rate of interest, and the increased cost of repairs, and (2) the new houses which we are to build must be better than the old ones. They must be adequately equipped, and provide more accommodation, and have more land attached to them. This inevitably means higher rents, and we are compelled to ask whether people can afford them. When we seek to answer this question we see how inevitably the housing problem is bound up with the problem of wages. The standard of housing is low among the workers because they cannot afford to set up a higher standard. Now, it is perfectly futile to build them ideal houses unless we also give them the wherewithal to pay the rent. But this prospect need not alarm us. A comparatively small addition to the rental not only makes all the difference between a poor house and a good one, but it makes all the difference to the health, happiness, and contentment of its occupants. I feel sure that if we could realise how much money we lose year by year merely through allowing our workers to be ill-housed, we should be forced to admit that our policy was not only inhuman, but utterly unsound from a financial point of view.

If this country is to be industrially efficient, and if we are to grapple successfully with the difficult tasks in front of us, and to face our heavy responsibilities courageously, we cannot afford to allow conditions to continue which undermine the national health and foster social discontent. Just now, we are witnessing the death of an old world and the birth of a new one, and we are building, not only for to-day, but for to-morrow. Let us see that, at any rate, the homes of the people are worthy of the momentous days in which we live.

DISCUSSION.

THE CHAIRMAN (Professor S. D. Adshead), in opening the discussion, said everyone present would agree with him that they had listened to a most interesting and illuminating paper. He thought that such a paper, dealing in so general, so illuminating, and at the same time so simple a way with the housing question ought to receive the widest possible publication. The author had pointed out the importance of education on the housing question at the present time, with a view to supporting the Government in its proposed scheme, and he very heartily endorsed that. If some simple, straightforward, lucid exposition of the housing question, such as the present paper, could be reproduced by the million and distributed to everybody, it would do much to dispel the appalling ignorance that at present existed on the subject. The author had pointed out the absolute necessity of insisting on a good type minimum house, and personally, without going into complicated financial and economic questions, he might say that he regarded the importance of every individual being well housed as so great that it was comparable with the importance of supplying pure water. It was just as unreasonable to expect citizens to live in dilapidated houses as it was to ask them to drink contaminated water. The author, who was the greatest authority in the country on the difficult question of how many houses were wanted, put the number down at 325,000, and thought it was possible to build that number in one year. That struck him as being rather appalling, and it would only be possible under one condition, namely, that the force came from the centre. If the matter was left to local initiative and local responsibility, not one-tenth of the number would be provided. It was because it was so necessary to depend upon central force that the subject of popular education was so vastly important. Everybody realised that a very large number of houses had got to be built, and realised the immediate importance of it, but everybody did not realise that that would not be brought about unless there was a certain amount of vital force exerted from the centre. That, of course, meant that parochial activities and parochial interests might have to be a little mutilated, but that could not be helped. With regard to the cost of land, two months ago he was at Carlisle, where he had been doing some work in the way of suggesting developments in the housing schemes of the Carlisle Corporation, and he was astonished to find that it was impossible to buy an acre of land in that town for the erection of the proposed houses at less than £1,500. He came back to London, and there met someone who was interested in land in Penzance, at the other extreme end of England, and who told him that about seventy-five acres of land quite close to Penzance had recently been sold to a shipping company at £75 an acre. Then, to take the case of London, the land in the Duke's meadows at Chiswick, about which there had been so much discussion, was offered by the Duke of Devonshire at £600 an acre. The situation was ridiculous, and he thought more transport facilities should be provided to open up competition in land and bring it all to a sort of normal level so as to adjust its value to its possible utility. With regard to the question of limiting the number of houses to the acre, he had worked out the subject very carefully, and at pre-war rates the difference in the rent obtained between putting up fifty houses on an acre of land at £500 an acre, and putting twelve houses on the same amount of land, having regard to reduced road widths and so forth, was only 9*d*. a week; that was to say, the actual return on the money spent would be the same if 6*s*. 9*d*. was charged for a house with one-twelfth of an acre of land as it would be if 6*s*. was charged for a house with one-fifth of an acre. Up to the price of £500 an acre nearly all the money went in bricks and mortar, a fact which people did not realise. With regard to the method of cottage building, *i.e.* the cottages crowded together along the road or spread out, the long-fronted cottage, or the short-fronted cottage, he had gone very closely into the figures, and found that, provided the modern narrow system of road construction was employed, and all the advantages of town planning of that kind, one could build five long-fronted houses—*i.e.* houses with a twenty-five-foot frontage—one after another, then two short-fronted ones, and then five long-fronted ones, at a cost of 5*s*. per cottage less than if all the houses built had a narrow seventeen-foot frontage and the road was a thirty-six-foot hard metal one. Therefore, by using the more beautiful, and the simpler, type of road, one could effect an economy which would enable one to build the more beautiful and healthy long-fronted cottages. There were two points he would like to mention in connection with his experience of cottage building. The first was with regard to the scullery. Some people said the scullery should not be made too big, and others that it should not be made too small, but he thought the important point about it was that the cooking-range should not be put in the scullery, because, if it was, the people would live there. The second point was that there was a tendency in the system of garden suburb building of the present day to go to almost extreme measures in

endeavouring to prevent any building whatever outside the lines of the main wall. That was a very excellent ideal, but it was almost impossible to realise it in practice. Quite recently he had been inspecting several housing schemes that had been completed, including one of his own, and in every case he found that things that were supposed to be kept in the scullery had been turned out into the garden. Wherever the scheme of housing had been one in which there had been no outhouses built it had always been found necessary to erect some kind of shed for the perambulator, mangle, gardening tools, bicycles, and so on; and architects who had to deal with the question must provide a properly designed shed for such things. With regard to the artistic aspects of the cottages to be built, there was no doubt that at the present time there would have to be a great deal of standardisation. However much one might dislike standardisation, 325,000 cottages could not be built each different from the other, and as much as possible would have to be done in that direction by providing interesting lay-outs. He thought there would be a great deal of cement used in their construction. Good bricks could not be obtained, so rough ones would be used, and they would be cemented over. Where cement was used it should not be left uncoloured or unwhitened. Nothing looked more dilapidated, after a year or two, than cement in its ordinary condition, and nothing looked more beautiful than cement if it was whitewashed, but it would have to be whitewashed every year, or at least every two years, in order to keep it clean and preserve its attractive appearance.

Mr. John Slater, F.R.I.B.A., in proposing a vote of thanks to the author, said that if anyone had had doubts as to the necessity of building a large number of houses in the immediate future those doubts must have been dispelled by the paper, but he was very anxious that due consideration should be given in any scheme to the undoubted difficulties of the problem. The Chairman had alluded to some of those difficulties, and the author had spoken of the inefficiency and insufficiency of a large number of the cottages in rural districts. Unfortunately it was practically impossible to build cottages in rural districts that would pay any reasonable interest on the capital outlay. He thought it ought to be made incumbent upon every landowner — and enforced by law if necessary—to erect a sufficient number of cottages on his estate for the people whom he employed there, not only in what might be called the residential parts of the estate, but also for the men employed by the farmers on the estate. The centre of deficiency in housing had somewhat shifted during the last three or four years. In very many places in the country large factories had been erected during the war, and a considerable number of small houses of a somewhat temporary nature had been built round them. Many of those temporary houses were far better than some of the permanent ones that existed at present; they would last for a certain number of years, and he hoped they would be taken into consideration in the immediate future, and that use would be made of them. He agreed with the author with regard to the necessity for transport facilities, but he was afraid there was a feeling among the working-classes that they must live near the place where they were employed. The great overcrowding and congestion in London arose simply from the fact that workmen, in order to be near their work, would pay for two rooms in a crowded street two or three times as much as they would have to pay for a cottage in the country. In the near future a number of factories would probably be erected for the purpose of manufacturing articles of which hitherto Germany had had a monopoly, and it was practically certain that those factories would not be built in towns but in the outskirts of towns and in the country. He hoped that in the future factories would never be placed in cities at all. In the last few years there had been a tendency for manufacturing concerns to carry their factories out into the country, with great benefit not only to themselves but to their workmen. He agreed with everything the author had said as to the horrible monotony and uniformity of the great majority of workmen's cottages, and as to the necessity for improving them, and he thought that attention should not only be devoted to their construction but to introducing a little decoration of a simple character into workmen's dwellings. If advantage was not taken now of the offer of the Government to subsidise house-building the opportunity might be lost altogether, and therefore the matter ought to be taken in hand at once. The author's suggestion of differential rating was very ingenious, but he could not help thinking there might be serious difficulties in carrying it out. He hoped it would not be thought that he was in the least opposed to the housing scheme suggested, but he wanted very strongly indeed to guard against what would be a perfect tragedy, namely, that houses should be put up where they were not wanted and where there were no people to inhabit them. He agreed with the Chairman that it would be a very great advantage if the paper could be widely distributed.

Mr. Henry R. Aldridge (Secretary, National Housing and Town Planning Council), in seconding the vote of thanks, wished to pay a tribute to the national importance of the work the author had done in regard to housing reform, not only in the early days of the Land Inquiry Committee but also in recent times, and especially in the last two years. With regard to the question of differential rating, he thought a difficulty would arise as to where the rate was to come from, because, if one rated only on a very small value and limited the rates on the cottages already built, an enormous burden would be thrown on the other rateable values in the town in order to make up the deficit. He did not know whether the author meant that

to be a forerunner of a movement to throw a great amount of the local burdens on the State, as, for instance, a greater contribution to education. With regard to the Chairman's remarks, the question of the variation in land values was most perplexing. There was no definite standard at all, enormous and quite inexcusable variations being found in a single county, but he hoped there would be an improvement in that respect in the future. At the present time he was engaged in obtaining from a number of local authorities statements of prices actually paid for land for housing schemes, and he found that in quite a remarkable way they were getting land at very low prices. He attributed that very largely to a fine sense of public duty animating many of the landowners of the country. He always urged local authorities to avoid the agent and go straight to the landowner himself. When they did that they were received in a much better spirit, and could sometimes obtain land at a very low price. A landowner who had given his sons to fight in the war would not treat the demand for land in a narrow spirit. With regard to the desirability of enlarging the walls of a town, only two days ago he heard from the city engineer of Leeds a most interesting example of that kind. The city of Leeds proposed to buy from a colliery company between seventy and eighty acres of land near Leeds at £40 an acre, and they had to spend another £100 an acre in dealing with the coal, which was nearly worked out. The land was right outside the city boundary, and they had decided to include the power to enlarge their boundary in a Bill which would be before Parliament next session. There was an old mineral line there which ran right into the heart of the city, and they were going to buy that line and run a kind of light railway on it. With reference to the number of houses to be built, over 300,000 was a very large programme, but if the figures of the number of men engaged in the building trade were examined it would be found that in England and Wales alone there were 800,000. He very strongly urged everyone interested in the subject to obtain a copy of the report of the Tudor Walters Committee and to study it closely, because it was a mine of useful information. That report estimated that the number of men required to build 300,000 houses in a year was 400,000, only half the total number engaged in the building trade. The question of building materials was one of the most difficult of all housing problems, and now that so many munition works were closing down and their employees being dismissed, it was time that the question of manufacturing material should be seriously considered. The Carmichael Committee was asked to deal with the subject, but its report said that the members of the Committee were not in favour of removing all control, and on the other hand they were not in favour of imposing control. The Government had decided to transform the Ministry of Munitions into a Ministry of Supply. The French Government had taken the same step, and had decided to throw the whole of the energy of that Ministry into producing the munitions of peace. The Minister of Supply in this country should be told to mobilise all the energy he could, and put as much energy into producing the munitions of peace as had been put into producing the munitions of war. Only then would it be possible to obtain building materials at a reasonable price.

Mr. Frederick Litchfield said that a report had just been issued on currency and foreign exchanges by a committee appointed by the Treasury. That report stated that the committee was aware that immediately after the war there would be strong pressure for capital expenditure by the State in many forms for reconstruction purposes, but that it was essential to the restoration of an effective gold supply that the money for such expenditure should not be provided by the creation of new credit, and that in so far as such expenditure was undertaken at all, it should be undertaken with great caution. The report went on to state that the necessity for providing for indispensable food supplies and raw materials from abroad, etc., would limit the savings available for new capital expenditure for a considerable period, and that the caution they advised was particularly applicable to far-reaching programmes of housing and other development schemes. The shortage of real capital must be made good by genuine savings, and it could not be met by the creation of fresh purchasing power in the form of bank advances to the Government, or to manufacturers under Government guarantee or otherwise, and every resort to such expedients could only aggravate the evil, and retard, possibly for generations, the recovery of the country from the losses sustained during the war. Having regard to that report, if the Government declared itself in favour of building houses, the Treasury would at once say that there was no money available for the purpose.

Professor W. J. Simpson, C.M.G., M.D., said the question of housing was a very old one. When the working-class Housing Act was passed millions of pounds were spent in demolishing slums, but slums were allowed to spring up adjoining those that had been destroyed, and unless some good scheme was adopted in regard to the development of towns, and good Building Acts were passed, the same thing would take place at the present time. Care must be taken that the million houses built should be healthy houses. For that purpose there should be plenty of space around them to admit, not only abundance of sunlight and fresh air into every room, but also to give a decent and safe playground for the children. There was going on at the present time in London a great deterioration in housing owing to the introduction of high tenement houses called flats. These immense buildings, erected by companies, were displacing the smaller houses, they were covering the former gardens and backyards of these houses, and were

provided with deep wells or ventilating shafts instead of wide and healthy open spaces. The result was that the lower rooms were dark and unhealthy, and there was no place for the children to play in except the street. If flats must be built it should be a law that behind each of them, and belonging exclusively to each set of flats, there should be provided a common grass lawn running the whole length of the building, and equal in width at least to the height of the building. This would correspond to the back garden of the small houses, and be a safe and healthy place for the children to play in. No attention ought to be paid to the cost of building. If people lived in unhealthy houses the Treasury had to pay in another way by providing hospitals, lunatic asylums, prisons and workhouses, and it would be found cheaper to provide good houses and in that way prevent disease.

Mr. Ewart G. Culpin (Garden Cities and Town Planning Association) thought one of the most encouraging remarks made by the author was that a Housing Department was going to be formed. It was one of the tragedies of the war that the Government at the time of the cessation of hostilities was absolutely unprepared in the matter of housing. The Housing Bill, which had been recently introduced in the House of Commons, was of a contemptible nature. The delay of the Government was inexplicable, and it was extraordinary that even now people knew very little of what was actually going to happen with regard to housing. At the present time he was acting as housing adviser for a number of concerns that were setting up factories in the country to deal with industries which before the war had been carried on exclusively in Germany. Those industries required within the next twelve months alone 7,500 houses, but they could not yet obtain permission to employ labour on the building of them, nor could they get any assurance as to what, if any, assistance would be given to public utility societies. With regard to the price of land, he knew of cases where £1,000 an acre or more was being asked for land which was not worth anything at all to its present owner. It was of no money value until somebody converted it into building land by the expenditure of many thousands of pounds. He had not found the patriotism amongst landowners to which Mr. Aldridge had alluded. They might have given their sons, but they intended to keep their land or to obtain a good price for it. Before people could live in any one of the cottages that were to be built, and before they began to pay rent for them, they had to contribute 2*s*. a week in rent to the landlord. That was an intolerable state of affairs, and until some legislation was obtained to alter it, housing schemes could not be satisfactorily carried out. One local authority was asked to pay £1,800 an acre for land. Everyone would join in abhorrence at the idea of standardising houses, but the suggestion of standardising parts of houses was one to which a number of the best architects were giving increasing attention at the present time. It had been worked out in such careful detail, that it must result in a considerable saving. In a housing scheme with which he was concerned it was proposed to ask the architects to work to a certain unit, so that although they might adopt any style of elevation and any design and size of rooms, within limits, it would be possible to give orders for windows doors, etc., of the same kind, and as a matter of fact some thousands of such things had already been ordered, and were being made in a factory which a fortnight ago was producing munitions.

The resolution of thanks was carried unanimously, and the meeting terminated.

Mr. D. R. Broadbent writes:—I am strongly of the opinion that the best solution to the housing question is in restaurant flats. In well frequented and busy thoroughfares, in large cities, I think flats with two restaurants attached would be the most economical. A restaurant on the ground floor of such a building would be open to the public, at a slightly lower tariff than the restaurant on the first floor, open to residents of the flats only. The two restaurants would be connected by food lifts; but no staircase or other means of passing from one restaurant to the other. A semi-circular aperture could be cut in the floor adjacent to one of the walls, between the restaurants, and a band-stand could be interposed accessible by a spiral staircase from either the lower or the first floor restaurant, kitchens for both would be either on the top story or in the basement, in communication, of course, by food lifts. The flats would be centrally heated throughout by a good system of hot-water radiators, which could shut themselves off automatically when the temperature reached the maximum height required.

SALT BEDS NEAR MATAMOROS (MEXICO).

Thirty miles from Matamoros and a few miles from the coast of the Gulf of Mexico are situated a number of salt beds, which are said to have during dry seasons an annual production of approximately 1,000,000 lb. The land in this locality, having been formerly the bed of the Gulf, contains a great amount of salt. During the rainy season the beds of the lakes and lagoons fill with water, which becomes salty, and upon its evaporation a crust of salt is left from one to three inches in thickness. The salt is gathered by the owners of the lands on which the deposits are located; it is broken into pieces with bars and shovels and conveyed in boxes to the place of storage, later being hauled by animal transport to Matamoros. Part of the output is used locally, the remainder being sent to other parts of Mexico.

According to a report by the United States Consul for Matamoros, the cost of gathering this salt is about 10*d*. a cargo (300 lb.), to which is

added a State tax of 7½*d.*, and a Federal tax of 1½*d.* The salt sells in Matamoros for about ½*d.* per lb., and is used for table and other purposes. No attempt is made to refine it, and while that next to the ground contains more or less foreign substance, the upper part of the salt crust is fairly free from sediment.

The output cannot be depended upon regularly owing to the fact that the salt is sometimes dissolved by rains during the "dry" season.

PAPER-MAKING FROM MEGASS.

Some particulars are given in the *West India Committee Circular* of a project to construct a megass-paper mill at Olaa, Hawaii, capable of manufacturing 16½ tons of paper a day. Its purpose primarily will be to produce the heavy mulching paper experimentally adopted in Olaa last year as a means of preventing the growth of weeds in the early stages of the sugar-cane crop. It is said, however, that the mill can be made to manufacture other papers of many grades, ranging from the ordinary brown wrapping paper and cardboard to super-calendered stock such as that used by magazines.

The amount of bagasse required for the output of 16½ tons a day will take only about 10 per cent. of all bagasse created in the Olaa mills, and this first plant will be so built that additions may be made later, until the entire bagasse out-turn may be utilised if that is found advisable and desirable. If megass paper proves all that is predicted for it, Olaa eventually should be producing something like 165 tons of paper a day. Should the project prove thoroughly successful in every way, and should it be taken up by the other plantations of the islands, it will develop a new industry in Hawaii, second in importance only to that of sugar production.

However, the Olaa mill probably will not be ready for operation within a year. The machinery is being ordered now, but because of war conditions in the eastern factories and in the arteries of transportation, no one can tell when the equipment will be delivered.

GENERAL NOTES.

Psycho-technical Examination of Railway Servants.—The Saxon State Railway submit their locomotive drivers and other responsible train attendants to certain tests in their psychometric laboratory at Dresden. The tests comprise strength of will and endurance and fatigue when there is bodily strain. The Dubois ergograph is used for the purpose, the object to be attained being the tracing of a fatigue curve. The forearm rests on a table; over the middle finger is placed a catgut loop, which passes over a pulley, the other end of the gut having fixed to it a weight of from 4 to 8 kilograms, according to the suitability of the subject under experiment. When the middle finger is bent, the weight is raised, and when it is relaxed the weight is dropped. The progress of this motion is traced on a drum. With each stroke the drum moves forward 1 mm., and every two seconds a clockwork arrangement records a time mark, so that fatigue in terms of time can be read from the final curve. In addition to giving the mean efficiency in metre-kilograms per second, the ergogram also shows the fatigue (*i.e.* decrease in efficiency) per minute, as well as the number of strokes or lifts which the subject has to make to do 1 metre-kilogram of work. This system, says the *Zeitung des Vereins deutscher Eisenbahnverwaltungen*, has enabled the railway authorities to place men in the jobs most suitable for them.

Measuring the Resiliency of Materials.—A device is described in the *American Machinist*, known as the "Widney" Resiliometer, for measuring the thickness, hardness, and resiliency of materials, such as felt, rubber, leather, and similar products. The instrument consists of a dial indicator on which is mounted a presser foot operating at right angles to the flat base of the machine on which the work is rested. The presser foot is pressed into the material being tested by means of a weight operating through a quadrant and a rack-and-pinion mechanism to the ball at the top of the dial indicator. In operation the quadrant is pulled forward and locked by means of a spring catch, when the material can be placed under the presser foot and the normal thickness measured. The dial is graduated in 100 divisions, each of which represents 0·001 in., but the device is provided with an auxiliary small dial for use on materials more than 0·1 in. thick, which would cause the main pointer to make more than one revolution of the dial. After the normal thickness of the material has been noted, the spring catch is released and the quadrant swung back until it bears on the ball at the top of the indicator. This impresses a force on the material being tested through the presser foot, and the reading now taken will give the relative hardness of the material. After this reading has been taken, the quadrant is pulled back to relieve the material from pressure, and the third reading gives the resiliency of the material.

American Forestry Units in France.—At fifty-three sites in France American Army forestry units were at work. The development of the lines of communication for the American forces called for a tremendous quantity of lumber for building construction, according to the *Engineering News-Record*. The programme included building docks at the base sections, wooden warehouses for the storage of supplies, barracks at cantonments, hangars and shops at aviation centres, poles for telegraph and telephone lines, duck boards and revetment frames for the trenches, and planks for road construction near the front. There are two units employed at present, representing a total of 15,000 men, including a number of experts from the *personnel* of the United States Forest service.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—December 20, 1918.

No. 3449. DECEMBER 27, 1918. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2.

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,449. VOL. LXVII.

FRIDAY, DECEMBER 27, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 1st, at 3 p.m. (Juvenile Lecture.) Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical Institute, Finsbury, "Liquid Drops and Globules." (Lecture I.)

The lecture will be illustrated with numerous experiments.

Special tickets are required for the Juvenile Lectures, and no person can be admitted without one. A few tickets are still left, and these will be issued to Fellows who apply for them at once.

COLONIAL SECTION.

A meeting of the Colonial Section Committee was held on Thursday, December 19th. Present :—

Lord Blyth (Chairman of the Section) in the chair; R. E. Brounger; Edward R. Davson; Edward Dent, M.A.; Carmichael Thomas; and George Wilson, C.B., with S. Digby, C.I.E. (Secretary of the Section).

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

Wednesday afternoon, December 11th, 1918; His Grace the DUKE OF PORTLAND, K.G., G.C.V.O., in the chair.

THE CHAIRMAN, in introducing the reader of the paper, said he believed that the Council of the Royal Society of Arts had invited him to take the chair that afternoon because he had the honour to be the Chairman of the Committee of the R.S.P.C.A. Fund for Sick and Wounded Horses. With reference to that fund, he might say, if the audience would kindly grant him a few minutes' indulgence, that shortly after the outbreak of war in 1914, the Royal Society for the Prevention of Cruelty to Animals offered its services to the Government for the alleviation of the sufferings of the horses and other animals of the British Army. The offer was accepted, and the Army Council signified its approval of a fund being started by the Society for the purchase of hospital requisites and other things for sick and wounded horses. (Of course, when he used the word "horses" he meant mules as well.) A special committee was formed to carry out the work, and its honorary secretary was the chief secretary of the Royal Society for the Prevention of Cruelty to Animals, Captain E. G. Fairholme, who, in the speaker's opinion, had carried out his duties with consummate ability and with great tact and unflagging devotion. During the whole period of the war the R.S.P.C.A. Fund had been the only one of its kind authorised and recognised by the Army Council. Many letters had been received from the military authorities expressing appreciation of the work carried out by means of the fund, and if time permitted those letters could be read, but he would not think of doing so in view of the paper which was to follow. Also, if time permitted, many particulars might be specified as to the various kinds of services which had been rendered. He would content himself with saying that the fund of the R.S.P.C.A. had provided veterinary hospitals to accommodate some 13,000 horses belonging to British, Canadian, Australian, and Indian units. He would like to add that these hospitals cost £100,000, and that quite recently the fund supplied fourteen motor ambulances, costing £1,100 a-piece, for the conveyance of wounded animals to the hospitals. It was only right for him to say that the public had been very generous indeed in its support of the work, and as Chairman of the Fund Committee he was glad to take the opportunity of expressing their grateful thanks to the public for its generosity. It also might be of interest to that audience to know that altogether £220,000 had been raised under the auspices of the R.S.P.C.A. For the purpose of co-ordinating the work of the fund with the Army Veterinary Corps, Captain Fairholme was, in October, 1915, appointed by the War Office Deputy

Assistant Director of Veterinary Services with the British Expeditionary Force, and he served in France for a very considerable time in that capacity, thus being able to direct the operations of the fund in such a manner as to secure the greatest possible benefit for the horses of the British Army. The speaker added that only two days previously he had the great pleasure and satisfaction of visiting a very large hospital for horses and mules of the British Army. It was No. 13 Veterinary Hospital, in the neighbourhood of Boulogne, and was under the able management of Major-General Moore, A.V.S., who had several other hospitals of the same kind under his supervision as well. He would like to say that he was extremely grateful to General Moore for the great courtesy and kindness he showed him: he was delighted with all that he saw at the hospital, and could vouch from his own experience as to the great care which was taken of the many patients—horses and mules alike—which were brought direct from the Front. The following interesting information was given to him on this occasion, and with their permission he would like to read it to the Society:—

"Since the commencement of the campaign no less than 689,387 animals (horses and mules) have been admitted to the veterinary hospitals and convalescent horse depots for treatment, and of this number 500,604 have been cured, and returned to the Remount Department for reissue to the Front. This figure represents 72 per cent. of admissions, which must be considered as most satisfactory, when one remembers that the admissions include many thousands of severe battle casualties and all the different forms of contagious disease. As far as contagious disease is concerned, the animals of the Force, on the date of the signing of the armistice, were freer than at any previous time during the campaign, which speaks volumes for the system of veterinary inspection and control which has been carried out. Mange, which has proved an absolute scourge in previous military campaigns, is now practically non-existent, less than 0·5 per cent. of the animals of the Force being under treatment for contagious skin disease of all kinds, of which a good deal less than half is mange. (Signed) J. Moore, Major-General, A.V.S."

His Grace added he thought this a most satisfactory statement. He apologised for having taken up so much time with preliminary remarks, and called upon Sir Frederick Smith to read his paper.

The paper read was—

THE WORK OF THE BRITISH ARMY VETERINARY CORPS AT THE FRONTS.

By Major-General Sir Frederick Smith, K.C.M.G., C.B., F.R.C.V.S.

When invited to deliver an address on the Veterinary Service in War, I doubted the necessity for so doing, for the subject had already been dealt with by Captain Fairholme in 1915, by Lieutenant-Colonel Rainey of the Army Veterinary Service in 1917, and by Captain Galtrey of the Remount Service in 1918. To Captains Fairholme and Galtrey my Corps is indebted for their appreciatory criticisms, while the public is under the obligation of receiving from their pens a picture of the veterinary care of animals in war which must have come as a revelation in humanity and organisation.

The popular conception of the Veterinary Service in war, prior to 1914, was not very creditable to human intelligence. I well remember a scientific friend expressing surprise that any organisation for the care of sick and wounded animals in war was necessary or practicable; he had a notion that something might be done for them during peace, but that in the complex of events associated with war nothing of a practical nature was possible, and the animals must be left to chance. Perhaps there were others of equal mental ability who thought the same, while it is certain that to the public generally the idea of any special organisation for the veterinary care of animals in war was altogether unknown. One of the objects of this paper is to show that the conservation of animal life in war is of paramount importance. It has not always been so regarded; up to and including the war in South Africa the history of the veterinary care of Army animals is sad reading, a story of suffering, misery and losses which can only fittingly be described as appalling. Humanitarian, and perhaps also financial, considerations are responsible for the change which has been wrought during the past sixteen years. I should not like it to be thought that the Veterinary Service was in any way responsible for this indifference. The veterinary reports furnished after every campaign for generations past dwelt upon the absence of all arrangements for the care of the sick, and the wastage resulting therefrom. They made suggestions for the future, and indicated the necessary organisation, but as a nation we are naturally slow to adopt new ideas, and intensely conservative; yet it is well known that disease and death are always more costly than health and efficiency.

We have, I am sure, to thank the factor of public opinion for the great change which has been brought about. For the best part of a century the same powerful lever has been working in the interest of the soldier, whose conditions of life have changed beyond all recognition. If we wish to learn the lot of the

soldier in war during the past and preceding centuries we have only to turn to the pages of Fortescue's "History of the British Army." How any men ever survived the absence of all organisation for their preservation and subsistence is little short of a wonder. Army animals have now had applied to them similar measures to those which have been found so successful and economical with men.

I have little doubt that there are many people who date the origin of the veterinary art from late in the nineteenth century, whereas, as a matter of fact, it is as remote in the history of the world as the beginning of historic times. I propose, very briefly, to take you over the ground, not only with the object of showing the antiquity of the veterinary art, but also of indicating the important part played in its development, during the early centuries of the Christian era, by veterinarians who were associated with the Army.

The earliest extant works on the diseases and injuries of horses belong to the fourth century of our era, and were written by army veterinarians of the Byzantine or Eastern Roman Empire, the chief of whom was one Apsyrtus, veterinarian in the army of Constantine the Great. The fourth century was not, however, the real starting-point of veterinary knowledge; there is ample evidence to show that there were skilled men in the times of Ancient Greece. Xenophon had written on the care and management of cavalry horses 800 years earlier than the time of Apsyrtus, and we know that his views, though twenty-three centuries old, are true to-day. Aristotle, who was contemporary with Xenophon, devoted the eighth book of his history of animals to a consideration of veterinary medicine; he wrote, of course, as a layman. The Romans, on the other hand, were not skilled in medicine or surgery; in fact, for five centuries the medical art was unknown in Rome, until they borrowed from Greece. If this was the condition of affairs in human practice, it is easy to understand the position of veterinary medicine. Varro, a soldier, who wrote in 36 B.C., and who appears to have explored every branch of human knowledge, refers to the ancient Greek veterinarians as "Hippiatroi." He was evidently familiar with their works, of which, unfortunately, nothing remains. He himself wrote on the diseases of animals, and it is doubtless due to such men that the Roman Army, in the second century of our era, possessed an infirmary for sick animals known as a "Veterinarium." But Columella spoke of the "Veterinarius," or animal physician, in 42 B.C. The irritating word veterinary is therefore extremely old; it disappeared with the final collapse of the Western Roman Empire, and is not met with again until the year 1528, though it does not appear in England until the closing days of the eighteenth century.

Among the contemporaries of Apsyrtus was one Chiron, whose work on veterinary medicine has come to light only in recent years. Shortly after Apsyrtus there lived a lawyer and gifted veterinarian, by name Hierocles, fragments of whose letters survive, and of whose works on diseases I have been fortunate enough to find two previously unidentified manuscripts in the British Museum.

Inspired by these gifted men, Vegetius, the Western Roman General, who flourished about the middle of the fifth century, wrote his remarkable treatise on "The Veterinary Art." He was not only a soldier, but a man of letters. Vegetius stands out in bold relief in the Western Roman Empire; deploring the low state of the veterinary art in Italy, he tells us that the study of animal diseases was regarded as a mean and contemptible occupation. Though 1500 years have passed since that was written, public opinion on this question has undergone very little change. The work of Vegetius may be read with interest to-day; he is very modern in some of his views, such for instance, as the absurdity of regarding outbreaks of disease as being evidence of Divine wrath. He urges the public in these cases to place their faith in medical aid, rather than in incantations and charms.

It is fortunate that, amid the disruptive influences of the following 1000 years, the work of Vegetius was spared. It was among the earliest books printed in Europe, being published in 1528. Two years later what was left of the manuscripts of the Byzantine veterinary writers, *i.e.* Apsyrtus, Hierocles, and their many correspondents, was published in Paris under the orders of Francis I., the title then given to the collection being "The Hippiatrica." How these manuscripts got to Paris is unknown; probably, with many others, they were brought from Constantinople to Italy by the Greek Scholars who fled at the fall of the Eastern Empire, and thence carried to France as loot during the Franco-Italian wars. It is interesting to note that a copy of the fragmentary manuscripts of these early Byzantine veterinary authorities is regarded as one of the literary treasures of the world.

This rapid, and necessarily very incomplete, outline will help to show you that the foundations of the veterinary art are not of recent laying, but belong to the history of the ancient world. As might be expected, army requirements stimulated interest in the matter. It was precisely during this period of the Hippiatrica, *i.e.* the fourth century, that masses of cavalry were coming into existence, and largely replacing infantry in the line of battle. The growth of the cavalry arm, and the development of veterinary medicine and surgery, were not a mere coincidence.

I must not occupy your time by giving an account of the veterinary art from the Renaissance to the present day; but one important epoch in its history in this country cannot be passed over. In the last days of the eighteenth century—to be precise, 1791—a French refugee established a veterinary school in London, on the model of those then existing in France. Thus, for the first time in England, properly trained men were supplied for the veterinary care of horses. The opening of this school was welcomed by officers commanding mounted branches of the Army. Troop horses had been decimated by contagious diseases, and the sole advisers were the ignorant farriers. Within five years of the opening of the London school, commissions in the Army were given to its graduates. This was the beginning of the Army Veterinary Service, the development of which must occupy our attention for a few minutes, in order that its position at the present day may be understood.

At the end of the eighteenth century, and for many years afterwards, regiments were practically the private property of their colonels. It was they who engaged the necessary technical staff, such as surgeons and veterinary surgeons, and these officials, it is interesting to note, were actually remunerated by certain stoppages from the soldiers' pay. The Government of those days starved the Army in every way, and insisted on its being self-supporting.

The method of caring for the sick animals of regiments on service was very simple. If they were not too ill to walk they were led along with the baggage; if too ill, they were left behind to look after themselves. Nor need we be surprised at this primitive arrangement, when much the same system was employed in the case of the men. The long years of peace which followed Waterloo were not calculated to develop either the medical or veterinary branches of the Army. Peace routine was simple: every regiment had its own separate accommodation for sick men and horses, and its own doctors and veterinary surgeons. The nurses, in both cases, were the untrained soldiers of the regiment.

The Crimean campaign revealed the impossibility of attempting the regimental treatment of the sick and injured. The lesson had to be learned that sick men and horses are of no fighting value, a clog on mobility, and that the sooner they are moved into hospitals away from their regiments, the better for both regiments and patients.

For years after the Crimean War, thinking men in the Medical Service of the Army were ever pressing forward a scheme by which the medical officers of the Army were to be withdrawn from regiments, and converted into a homogeneous body with a subordinate technical staff under their own control, and hospitals under their own management and administration. Bitter and prolonged was the opposition to reforms of such obvious utility and humanity, but gradually each point was conceded until the Army Medical Corps was born. I need not refer to its magnificent work, nor the extraordinary manner in which it has controlled disease. It has recently been shown that in previous wars, from ten to fifteen men have died of disease to one who has died at the hands of the enemy; in the present war, one man has died of disease to every ten whose death was caused in the field.

It is self-evident that a scheme suitable for sick and wounded soldiers was capable of being adapted to the requirements of sick Army animals. The Veterinary Service urged that its scattered and impotent components should be formed into a single body under its own officers, and given facilities for dealing with disease and injury on an organised basis. This scheme has taken nearly forty years to accomplish, and the only qualification I possess for appearing before you to-day is that I am the one survivor at present in active employment —though as a "dug-out"—who has witnessed the entire transformation, and, further, I have been privileged to assist in its construction.

It is a remarkable fact that the people who are most anxious for the suppression of disease are those whose financial interests would appear to suffer seriously by its obliteration. More than two thousand years ago, Plato wrote that medicine was the science of health. The present position of preventive medicine in this country is due solely to the persistent hammering of the medical profession, which has resulted

in an enormous improvement in the health of the nation, but much remains to be done. It may not be known to you that statistics have recently been published, which show that only one man out of every three in the prime of life is capable of being passed fit for service in the front line! This national reproach is far more difficult to deal with than unsoundness in horses, but even there, where the matter is under the direct control of the individual breeder, little but indifference has, in the past, been shown to the laws of heredity, so far as they affect the question of disease or transmissibility of unsoundness. The serious prevalence of consumption among our dairy stock is another reproach, of the removal of which at present there is no indication. Yet such is possible.

The fact is that the public do not appear to be seriously interested in the prevention of disease. Far otherwise is it in the question of treatment; they love medicine, and especially nostrums, for which they are cheerfully prepared to pay the Exchequer £300,000 a year in stamp duty alone! Similarly, the entire function of the veterinary profession, according to the public view, is the treatment of disease. I am anxious to remove this erroneous conception, and to impress upon you that its great office is prevention. From the date of the first Army Veterinary Service in 1796, the campaign against disease has been going on. As we have seen, it was the appalling losses due to contagious diseases among troop horses which created the Service, and within a few years of its formation matters had improved beyond recognition.

Every step in the fight against disease has to be based on precise scientific knowledge. Very occasionally a truth is obtained by accident, as, for example, the protection afforded against smallpox by inoculation with cowpox, but accidental discoveries are rare. It was the patient study of the mosquito, flea, louse and bed-bug which showed their connection with malaria, plague, trench-fever and typhus. It was the study of certain species of blood-sucking flies and ticks which revealed the true nature and origin of a series of plagues which still remain incurable, and are capable of destroying the whole human and animal life of a sub-continent.

I am endeavouring to show that the importance of veterinary hygiene and veterinary preventive medicine has been overlooked by the public. These play the largest part in the work of the Army Veterinary Service, for the chief losses among animals in war are not due to battle casualties, but to disease and injury. Contagious diseases have to be guarded against by the careful inspection of all animals, their introduction into the Service has, if possible, to be prevented, and should they gain admission their early detection and obliteration is of paramount importance. In times of peace this is not difficult, but in war it is otherwise, for not only are the risks of infection much greater, but the facilities for proper inspection are necessarily infinitely less perfect. Moreover, there is the daily risk of fresh infectious material being introduced by the constant influx of new animals to replace wastage.

Injuries are controlled by a precise knowledge of how they are produced. Let me illustrate this point, which otherwise would appear to be a mere platitude. Sore backs, sore shoulders, head-rope galls and kicks from other animals, are among the prolific sources of injury in the field. The trained eye can recognise at a glance an ill-fitting saddle or collar; it can recognise a head-rope so fastened that it is bound to cause injury, and can prescribe means of restraint for kicking horses which considerably limit their activities. Knowledge of this kind is designated "horsemastership," and the man who possesses it is a valuable asset to the State. He must also understand how animals should be fed, acquire an acquaintance with the various foods employed, and the elementary principles of nutrition. He must always be learning, for these questions are not so simple as might appear, and the knowledge cannot be acquired by reading. An apprenticeship of five years under a good horsemaster is necessary, in order to gain a working acquaintance with the subject. Two thousand three hundred years ago Xenophon wrote that the eye of the master makes the horse fat. This is an axiom in horsemastership, for there is nothing capable of taking the place of constant supervision. We must remember that when animals are tied up they cannot look after themselves.

It will be evident to you that horsemastership in the present war has left much to be desired, through the pardonable ignorance of those in charge. Officers and men without the most elementary acquaintance with horses in civil life, have found themselves responsible for the care and management of a strange and capricious animal. Among the many difficulties of the new Army there was none that it had to face greater than this; it is a subject in which information could not be obtained by any other means than that of practical experi-

ence. Nearly all the painful and frequently fatal diseases of the digestive system of the horse are due to errors in watering, feeding and work. The principles governing health and efficiency are hard and fast, there is no compromise, though under the conditions of active service much may have to be done which we know to be wrong in practice, but military necessity knows no law.

We must, however, leave the questions of the prevention of disease and injury, and of the promotion of health and efficiency, in order to outline the methods of dealing with sick animals in war.

I am now about to tell you how 1,300 officers* and 27,000 soldiers, exclusive of 6,000 coloured men, are employed as a corps in the various theatres of war in looking after questions of health and disease as affecting all classes of Army animals. Let me remind you that the horse is not the only animal in the Service. Though the public thinks in terms of horses, we must not forget that the mule is largely employed, while thousands of oxen and camels are employed in African, Egyptian and Arabian theatres of war. All these different animals come under the care of the Veterinary Service.

We will begin our study of the question by taking the smallest complete unit of all arms, *i.e.* the Division.

Every division of our Army is provided with a staff, consisting of officers, non-commissioned officers and men of the Royal Army Veterinary Corps. Each veterinary officer of the division has charge of a certain number of animals, and for the carrying out of his duties is responsible to a senior officer, known as a Deputy Assistant-Director of Veterinary Services. This latter officer is in turn responsible to the Assistant Director of Veterinary Services of the corps of which the division forms a part, while the corps officer is responsible to the Deputy Director of Veterinary Services of the Army to which it belongs. The Deputy Directors of armies are, in turn, subordinate to the Director of Veterinary Services at General Headquarters. This is the chain of administrative responsibility by which the whole veterinary machinery works, and by which its efforts are directed and co-ordinated. It is the mechanism by which the humblest animal in the force receives veterinary attention from the moment of its being ill or injured, which directs its steps to hospital, and finally returns it to duty. No distinction is made in the matter of solicitude or care between the transport mule and the officer's charger.

* Practitioners from every quarter of the Empire volunteered their services.

Every division possesses a special veterinary organisation known as a Mobile Veterinary Section, the function of which is to form a combined collecting station for the sick, and a field veterinary hospital. It is composed of an officer, non-commissioned officers and men of the Royal Army Veterinary Corps, and is provided with its own transport for stores and equipment. Wherever the division goes its mobile veterinary section accompanies it. The advantage of bringing the sick of a division together for treatment is obvious, for not only is a sick animal a clog on the mobility of the battery or regiment to which it belongs, but there is no one to look after it without depleting the fighting strength.

The cases sent to a mobile veterinary section are broadly of two kinds: those which will be fit again in a few days and those requiring prolonged treatment. The governing principle in working a mobile section is that it must evacuate its serious or prolonged cases, in order to continue to perform its function as a collecting station in the field. The location of the mobile section is known throughout the division, it flies a distinguishing flag, and at night distinctive coloured lanterns are displayed. In stationary warfare it is connected up by telephone with the headquarters of the division, and care is taken in selecting its site that suitable accommodation is provided. For example, it is no use locating a mobile veterinary section some distance from a water-supply, or away from a main road.

In mobile warfare the section, in addition to receiving sick, has also to collect any animals abandoned by the division. There are always some which at the last moment are found unable to accompany their units, and these are left behind with the full knowledge that they will not be neglected. When a division is moving, its mobile veterinary section is the last to march off, and time is thus given to collect waifs and strays, and to make a final evacuation of those animals intended for hospital.

Every animal sent to a field veterinary section is accompanied by a form, which gives the name of the unit to which it belongs, the disease from which it is suffering, and a description of the animal for the purpose of identification. On admission this is checked, the diagnosis verified, and a serial number allotted, which is placed on a label tied to the head-collar. A

special coloured label is also tied on, summarising the ascertained facts regarding the cause of inefficiency, a white label being used for medical cases, green for surgical, red for contagious, and blue for casting. In addition each animal bears a stencil mark in paint on the quarter, showing the number of the mobile veterinary section to which it belongs.

A careful examination of all patients received by a veterinary section is of the utmost importance, for it is here that cases of contagious diseases may be caught in their earliest stages. If the system described is followed out, it is known at once to which unit of the division the animal belongs, and notification of the existence of contagious disease is sent it as a warning.

No more important duty exists than the early and thorough examination of the sick, otherwise cases of incurable and highly infectious diseases, such as glanders, will be sent back to the base, and mixed up on the way with unaffected horses. Great judgment is also required in deciding which of the ordinary cases may with advantage be retained for treatment, and which should go back to base hospitals. Every animal sent back unnecessarily is a loss to the division, and a source of expense to the State.

What I have just described to you is the first procedure in dealing with sick animals in the front line. The second step is as follows.

When a mobile veterinary section clears out its sick, they are handed over to a formation known as a *Veterinary Evacuating Station.* This is not a divisional unit, but belongs to the corps of which the division forms part. Each corps has one evacuating station, charged with the duty of receiving the sick from all the mobile veterinary sections, and transmitting them to the base veterinary hospitals. These evacuating stations are fixtures, located near to corps railhead, close to a water-supply and main road, and, if possible, shelter is provided by tents or in billets. The stations fly the usual distinguishing flag, while notice-boards and finger-posts at cross-roads indicate their locality; their position is also published in corps orders.

Every animal forwarded to an evacuating station appears on a roll furnished by the mobile section; this gives the information contained on the coloured label previously spoken of. Labels get lost, and are very often eaten by neighbouring animals; in fact, the problem of field marking for the purpose of identification is not entirely solved at the present time, though more or less ingenious devices have been employed.

The sick in the evacuating stations are capable of being more thoroughly and deliberately inspected than is often possible in a mobile veterinary section. The diagnosis is again checked, and a rigid search made for contagious and infectious diseases, as it is most important that they should not escape undetected from an army area. So important is this that a certificate has to be rendered to corps headquarters specifying that each animal admitted to the evacuating station has been inspected and stating the result. This inspection is a part of the sifting which began in the mobile section and which terminates, as we shall see, only when the animal is again fit for duty. It is the essence of veterinary supervision, and nothing can replace it. Every case passing through an evacuating station, together with its disposal, is entered in a book, and from this, totals are supplied at the end of the week to the corps headquarters concerned.

The sick are sent to the base by the evacuating stations two or three times a week, empty supply trains being utilised, or a special sick horse train made up. A train load is usually 280 horses, carried in thirty-five trucks. On no account is the evacuating station allowed to become congested, otherwise its functions are impaired, and above all there is a delay in getting the more serious cases under treatment. In some places evacuation may be carried out by water transport, and if the distance is not considerable suitable cases may march by road. Prior to evacuation all surgical cases are dressed, and first-aid dressings accompany the party. The surgical and medical cases travel in their groups, and the contagious cases travel in trucks on which is marked the instruction "To be disinfected." One attendant is told off to every two trucks; forage and a good supply of drinking water go with the animals; every evacuating station holds on charge large water bags for this purpose. Petrol tins and cartridge containers were at one time employed on these trains, and were found most useful for carrying water. Each evacuating station possesses a motor ambulance, the majority of these being gifts. From all sides one hears of the enormous value of the ambulance service in the present war, especially in France, where it has received its full development. Some hundreds of ambulances are employed in the Veterinary Service, many

being motor ambulances, each capable of taking two horses.

The evacuating station having entrained its sick for the base, the operations of the second piece of machinery in the scheme come to an end, and the third takes up the work. These are the hospitals found at, or in the locality of, the various bases established for the armies, each group of hospitals being told off for a definite portion of the fighting line. A group consists of two, three or more hospitals, viz., a *Reception Hospital*, a *General Hospital*, and a *Mange Hospital*.

When the train arrives at the *Reception Hospital* the cases are taken to the admission section, where the serial numbers, descriptions, and diseases are verified. Here they are marked for retention, transfer, or disposal, after being grouped into surgical, medical, contagious diseases, and mange, etc. The reception hospitals retain nothing except very serious or slight cases—the former being unfit to be moved, and the latter likely to be so short a time under treatment that it is economical to hold them. These reception hospitals have to be prepared to deal with two or three days' admissions, and are generally for 500 to 750 cases. During their stay in the reception hospital, the animals are tested, by what is known as the mallein test, to ascertain whether they are free from glanders, so that forty-eight hours are spent here; this time is occupied in grouping the sick and attending to their immediate requirements. All animals that pass the test for glanders can now be disposed of by transfer to the other branches of the base hospital system. This is carried out by the *Transfer* section of the reception hospital, which takes over the various surgical, medical and mange groups. From these groups cases are drafted to the general and mange hospitals in any number desired, the available accommodation at each hospital being previously known.

The *Disposal* section of the reception hospital deals with the cases for destruction or sale, the latter being handed over to the Remount Department.

A "treatment card" for each patient accompanies it wherever it goes, so that any change in diagnosis, or the development of a new disease may be noted. The card explains what the patient is unable to express, and is also a complete record of the animal while under treatment; further, it indicates how long any case has been in hospital, for there is a time limit, generally placed at three months, beyond which it is not economical to retain an animal.

We must now look at the *General Hospital*.

These are designed for 2,000 cases, and are generally divided into eight sections or subdivisions, each being told off for a certain class of case—for example, lameness, surgical foot cases, other surgical cases, pneumonia and catarrh, debility, contagious diseases other than mange, etc. No case of mange is admitted to a general hospital; should one occur, it is transferred to a mange hospital. On arrival at a general hospital the cases are verified from their treatment cards, and posted to their proper wards. It is evident that the experience gained by officers in their special class of case is unique, and their expert opinion of the utmost value to the patient.

As an animal in any of the hospital wards becomes convalescent, it is told off to a definite portion of its own ward for special feeding and exercise, with the object of getting it fit for work, and twice a week the cured cases in each ward are sent to the *Discharge* section of the hospital. Here the animal receives an increase in food and exercise, and when quite fit for work is again tested for glanders; if passed free it is transferred to the nearest remount depot for issue to the troops.

Cases of debility take a long time to recover, and for these special *Convalescent* depots exist, where the animals are at liberty in the open during the day, and housed at night. Some of these convalescent depots occupy a large tract of country; one of nearly 3,000 acres, was the first chosen, and held 4,000 animals. The large majority of these during the summer are left out day and night, only the weaker animals being housed. During the winter the numbers in a depot are reduced, and all the animals housed. The principle of construction employed in these depots is to have a series of well-fenced enclosures, each with its own open buildings and water-supply, with facilities for inspection, exercise, watering and feeding; each group has its own exercising ground. The object of this system of separation is to prevent extension of contagious diseases should any appear, and, to make doubly sure, each group is subdivided into smaller groups of fifty horses. This not only gives additional isolation but secures individual attention. It is very easy to overlook a case in a mob of 1,000 animals; it is practically impossible when the group is reduced to fifty.

You may, perhaps, be surprised at the care

which is paid to the isolation of the horses into small groups, but you will remember that the animals in these convalescent depots are allowed their freedom, and in consequence mix with each other. The horse is the most sociable of animals when with his fellows; he has his friends whom he nibbles and rubs against, and also his enemies whom, if he is the weaker, he avoids. In spite of the series of systematic inspections which have been carried out before he gains admission to a convalescent depot, he may nevertheless, be harbouring infectious disease in a hidden form, which later becoming developed will certainly infect the other animals in the group. Should such a case occur, the risk of infection is reduced to relatively unimportant numbers by the system of small groups. In this way infection of convalescent depots is prevented or controlled. The rule, however, for preventing infection is that no animals are sent there except those requiring a rest owing to debility and exhaustion; no case of disease, and nothing requiring active treatment is ever knowingly admitted.

On arrival at a convalescent depot each animal is carefully examined in order to see that it fulfils the required conditions; those refused admission are returned to their hospitals. The serial numbers are verified, hind shoes removed to prevent damage from kicking, and the whole party remains in isolation for fourteen days, during which time it is given the full benefit of the depot system of nursing. At the end of this period the animals are passed out of the isolation block, and classified according to condition and strength; the weaker ones being kept together. This not only ensures the necessary quietude and rest, but a better distribution of food, for the strong horse will always rob the weak. Horses are very human in some of their characteristics. The diet is most carefully regulated, because an exhausted horse cannot digest whole or raw grain.

As the animals improve in condition they are gradually promoted to the block dealing with those being got ready for discharge; here the feeding is more liberal, and the exercise increased. From this group animals are selected once or twice a week for issue to remount depots, all being tested for glanders before being sent away.

These convalescent depots are organised on the principle that horses at liberty can do a great deal for themselves where proper arrangements exist; for instance, the exercise is carried out on a large semi-circular track which communicates with each enclosure, so that the fifty horses are exercised together, not by being ridden, but by trotting or cantering around with no weight on their backs, as you will presently see on the screen. The pace is regulated by one or two mounted men. Having completed their exercise, the fifty are returned to their own enclosure, and the next batch taken out. It will be obvious to you what a saving in labour is effected by such a system.

There is no part of the method of restoring war-worn animals which more requires a thorough and perfect system than a convalescent depot. Non-recognition of this in previous campaigns has been productive of enormous losses by the spread of disease. Not the least of the triumphs of the Veterinary Service in war has been its organisation and management of convalescent depots.

Mange Hospitals, as their name implies, are distinct institutions for the treatment of the highly contagious disease known as mange. It may or may not be known to you that mange is due to a special variety of insect or mite, of which there are two serious types in the horse. One lives on the surface, the other in the depth of the skin. The disease caused by the latter is infinitely more difficult to cure.

In the organisation of a mange hospital the group system is, as usual, adopted. The animals on admission are first classified according to whether they are suffering from the ravages of the surface parasite, or those of the deep-seated one. They are next grouped according to order of severity, all cases of equal intensity being kept together.

The first important point to decide on admission is the type of disease. This is settled by the use of the microscope. Every case has to go through this routine, and as diagnosed it is sent to its proper ward. If, in addition to mange, the animal is suffering from surgical trouble or other form of disease, it is grouped accordingly, so that the two distinct conditions may be simultaneously dealt with.

The routine treatment of mange may interest you. The cases are first clipped, either by hand or power-driven clippers. The body is then washed to get rid of dirt and such like, and finally the animal enters a swimming bath containing an agent which kills the parasite. The bath may strike you as a difficult measure to adopt, but it is far otherwise. A bath is made by digging a narrow trench to a certain depth, rendering its sides and bottom water-tight with cement, and arranging it so that the animals

enter at one end, are completely immersed, and swim the length of the bath to the outlet, which is provided with a ramp, up which they walk to a dripping pen. Here the surplus material is removed, and the patients walk about until dry. Two, three or more such baths may be needed to ensure cure, for though the insects may be killed, the eggs they lay are very resistent, and will hatch out later and re-infect the host. We know that a few days suffices for the hatching out, so that the bath is repeated until the skin is no longer itchy, and the new coat is seen to be growing on the bare surface.

The bath is not the only method employed in treating cases of mange; sulphur fumigations are used, and the French authorities have largely adopted this method. It requires the construction of special stabling, for the animals must be so placed that they do not breathe the gas. The head of each projects from the fumigating chamber, and a padding around the head prevents the leakage of gas. The whole surface of the body is exposed to the fumigation for half an hour.

Vapour baths are also employed, not only with the object of getting the animal's body clean, but also to facilitate the penetration of the subsequent dressing. Incidentally it may be mentioned that the boiler furnishing the vapour bath also supplies steam to the swimming bath, so that in winter the animals enter warm instead of cold water.

We have previously seen the system of grouping mange cases according to their nature and severity; they are also grouped in the ward according to the progress of the case. Beginning at the bottom of the stable, they gradually work up as they improve, until they reach the top, by which time it is hoped they are cured. Here they remain fourteen days under observation, any showing signs of itchiness being sent back for further treatment. Those showing no further signs of being itchy are drafted to the discharge section of the hospital, where they remain under further observation until considered safe for issue. During the whole time they are under treatment the patients are liberally fed, without which recovery would be greatly delayed; they are also exercised daily on the automatic system.

Mange is the chief animal plague of active service; it was not always so. Glanders at one time held the predominant position, but applied science has reduced the ravages of this disease to almost a negligible quantity, and we are no longer harassed by its existence and persistent spread. Far otherwise with mange; we do not know the life-history of the insect apart from the host. We know how the disease spreads, and that in three months a pair of insects can give rise to one and a half million descendants, but we do not know how it is that animals sent into the field, absolutely free from mange and never during their service having been in contact with the disease, may contract it under the conditions of war. The same remarks apply to lice, both in animals and man. No amount of dirt by itself can lead to the production of a living insect, or any other living matter; life can only spring from pre-existing life.

I must, however, leave the subject of mange to conclude the account of veterinary hospitals.

The public conception of these would probably be represented by groups of tumble-down buildings, reposing in winter in a sea of mud, and surrounded by fœtid manure heaps, the sick being overcrowded in dark stuffy stables, unventilated and undrained, such as the majority of the working animals in civil life in this country have to endure. The real picture is very different, and shows well laid-out blocks of stabling, comfortable, ventilated and drained. There is no sign of a manure heap, for in this place the highest degree of sanitation is observed. Well-made roads intersect the buildings, grass lawns exist between the blocks, flower gardens are encouraged, the whole place giving the impression of comfort and civilisation.

These hospitals are the pink of neatness and scrupulous cleanliness, of order, system and method. The watering and feeding arrangements are as perfect as modern science can render them, the whole of the food being prepared by machinery. A system of competition and healthy rivalry is encouraged between the various hospitals to ensure that the highest possible standard is obtained. There are always original and progressive men to be found in every large community, and specially selected veterinary officers are placed in command of our hospitals with a free hand to improve, and instructions never to think that finality has been reached. In one hospital in France the very chains which tie up the horses shine like silver; none of it is hand labour; the chains go into a rotating vessel every day and polish themselves, and the motive power which cuts the chaff and crushes the corn burnishes the chains. In another hospital advantage has been taken of a supply of marsh gas from a large disused manure-pit; pipes are driven

deeply down into the vegetable mass, and the gas led to the hospital, where it is lighted and boils the food for the sick which thus costs not a penny for fuel. If the animals are so well looked after, you can imagine the care taken of the men, and the comfortable conditions in which they live. They have their flower and vegetable gardens, recreation-rooms and library, and at least one hospital has a band. Far better work is obtained from men when they are well cared for.

Wherever we look in the various theatres of war—France, Italy, Egypt, Salonica, Mesopotamia, or East or South-West Africa, the veterinary hospitals are on a sure foundation. They are modified to meet local conditions and requirements, also climatic needs, but the same principles are observed—system, organisation, and whole-hearted devotion being the watchwords.

The *Diseases and Injuries* of active service can only be very briefly dealt with. You will have gathered from the few remarks already made what a big subject it is, representing nearly the whole of animal inefficiency in war. A visit to a veterinary hospital in any theatre would reveal very few cases due to battle casualties, not for the reason that these do not occur, for the horse is a far larger target than a man, but because such cases are usually dealt with on the field by destruction, only those being reserved for treatment which offer a prospect of complete recovery. Nothing short of complete recovery is of the least value where animals are concerned. In the matter of treatment, modern methods are adopted, and I may tell you that surgery has made many advances during the present war. Injuries and poisoning from gas attacks have been frequent, and it may be known to you that horses in the front line wear gas-masks. I will show you presently on the screen the destructive effect of gas on the surface of the body; the pictures are unique, and the artist a non-commissioned officer in the Royal Army Veterinary Corps.

Of mange I have already told you sufficient, and you will be able to visualise the insects at work when I come to the lantern demonstration. Of the pest *Lice* I have not previously spoken, though the subject is full of human interest; men are more easily affected than horses, and in days long gone by the infestation in peace time of people of position was not regarded as disgraceful, whilst among the poor not only was the presence of lice looked upon as an indication of good health, but the wanderings of these disgusting parasites on the head gave early warning of a change in the weather! In the days of Queen Anne we have it left on record that hunger and lousiness were the two distempers which affected the soldier in war. The louse insect is not difficult to kill, but the egg is very resistent, and so causes repeated infection. *Ringworm*, another troublesome affection, is due to a vegetable fungus, of which I will show you a picture. *Glanders* you have already heard a little about, and a picture of the organism which produces this loathsome affection will be shown you. Perhaps I may here explain that the reason why this disease in any army has lost its terror is the advance of scientific knowledge.

A Russian veterinary surgeon discovered the fact that if the organism of glanders were grown in broth, and subsequently the whole mixture killed by prolonged heat and then filtered, the filtrate, known as mallein, if injected into a normal animal produced no effect, whereas if the horse were glandered a painful swelling arose at the seat of inoculation. This constitutes the mallein test to which I have so frequently referred. It was the greatest veterinary discovery of the nineteenth century, for it has enabled us to detect the presence of the disease at a stage when the animal cannot communicate it to others, and in this way to obliterate the pestilence. It is sad to relate that the discoverer subsequently died from glanders contracted during his investigations.

Strangles is a highly infectious disease common among young horses, and exists to an extraordinary extent among the animals collected on mobilisation. Its cause is a very small organism capable of being seen only under a high power of the microscope. It was the most serious pest we had to deal with at the beginning of the war. It frequently leaves behind it permanent inefficiency.

Contagious *Pneumonia* of the horse has led to an enormous monetary loss. During the early months of the war an average of thirty deaths a week for several months were occurring in one hospital in this country from this cause alone. The fat and young were the chief victims. Pneumonia is also the chief cause of loss among animals on board ship. Horses are not the only victims of contagious pneumonia; cattle are affected, and our transport oxen employed in the African campaigns have suffered seriously from this disease.

This reference to German South-West and

German East Africa suggests the desirability of mentioning the other animal plagues existing in that continent, which have been responsible for enormous losses among military animals.

No more terrible pest exists than *Cattle Plague*, which is capable of killing off nearly the whole stock of a country. It has been a serious trouble in German East Africa, military operations having spread it far and wide. Fortunately it is possible, by inoculation, to protect animals against the disease.

The ravages of the *Tsetse Fly* you may have heard of. The part played by the fly is that it is the carrier of the disease, which is due to a large and peculiar organism in the blood, of which I will show you a picture. The fly is a blood-sucker, inhabiting well-defined zones of country, through which no animals can pass without becoming infected. The disease simply sweeps away the animal population, nor are its ravages confined to animals. A fly of the same species inoculates man with sleeping sickness. There are no less than ten clearly defined animal plagues due to different species of this organism. All of these plagues are not found in Africa: one affects India, another South America, and no cure is known for any of them.

East Coast Fever is an African disease of cattle, slow in action, but capable of inflicting dreadful losses. It also is due to an organism in the blood, but one of very small size. The disease is transmitted solely by the bite of an infected species of cattle tick, of which I will show you a picture, and you will also see on the screen how the ticks on animals are destroyed by arsenical baths.

The last African plague I will mention is commonly known as *Horse Sickness*. The organism which produces this is so minute that it has never been seen, and it readily passes through the pores of a porcelain filter. The disease is seasonal, and probably transmitted by a species of mosquito. It is a plague of terrible intensity; in a few hours hundreds of animals may succumb.

Less alarming than the African plagues I have mentioned, but still very serious, is *Anthrax*, a disease widely spread over the world, affecting almost all animals, including man, but especially horses and cattle. There have been heavy visitations of anthrax among our troops operating in Palestine.

There is a curious group of diseases which exhibits itself by *Ulcers* on the limbs and surfaces of the body. Two members of the group are highly contagious, one is due to a peculiar vegetable organism circulating in the lymph vessels, of which I will show you a picture. Should a trace of the discharge from one of the many ulcers gain access to a wound in a healthy animal it sets up the disease. You can picture what it means if a case finds its way into the surgical section of a hospital. The affection lasts for months; it has given considerable trouble in Italy, but less in France, among our forces, though the French Army has suffered severely.

When large bodies of animals occupy the same camp for any length of time, especially in bad weather, the ground becomes foul to an extraordinary degree. This produces inflammation of the legs and parts above the hoof, the skin becomes gangrenous, and the hoof may even rot off. You will understand how difficult it is to combat such conditions, when military necessity demands that animals shall remain in a foul and contaminated locality; the disease can be controlled only by clean camping grounds and dry weather.

I must now make reference to the very large group of cases due to *Exhaustion*, the result of over-work. Fortunately there has been no insufficiency of food in the present campaign, owing to its being mainly a war of position, but when war is mobile it is impossible to carry bulky material like hay in anything like sufficient quantities, and grazing has to be resorted to if time permits. Even an abundance of food is no compensation for over-work and strain. The condition of the ground in France, and especially in Flanders, is common knowledge. Two and three teams of horses have had to be employed to do the work of one, and when animal labour has absolutely failed, the guns and waggons have had to be man-handled. Age is another potent factor in the production of exhaustion; an old horse may easily be killed by one day of over-work. The exhausted war horse is a pitiable sight and many never recover. A cold or wet night kills off scores. Nursing, rest, shelter, and proper diet are the only remedies, and I have given you a detailed account of how this treatment is carried out in convalescent depots.

Saddle and *Harness Galls* are the bane of active service. It would require a special series of papers to give you any real insight into the many causes operating in their production, and it needs several years' experience to learn practically how they may be prevented. Saddles and collars which fit horses in good condition

do not fit them when the parts become smaller through loss of flesh, nor will the most perfectly fitting saddle maintain a back free from injury when men have to remain mounted hour after hour. Under these conditions the skin actually dies through continuous pressure. I have briefly mentioned these two causes of sore back as giving you some notion of the magnitude of the difficulties of prevention, but there are many other causes in operation which are theoretically preventable, though in practice not always so. It is a common error to compare the shoe of a horse to the boot of a man—they both protect the feet, but there the analogy ends. The saddle of the horse may aptly be compared to the boot; both must fit, neither must be too large nor too small; a wrinkle in the sock or a knot in a lace may inflict considerable injury, for the reason that the boot must be free from all irregularities. You can imagine what it means to a back when the saddle blanket wrinkles, or a cake of mud exists between it and the skin, or the loose end of a strap finds its way under the saddle. Yet any of these things may readily occur when animals are saddled up in the dark. Such causes, however, cannot compare with the injury resulting from the arches of the saddle resting on the spine. The condition of back arising from this cause has to be seen to be realised.

I have yet to mention a serious disease among horses known as *Lock-jaw*. It is invariably the result of injury, and the chief seat of such injury is the foot. I cannot tell you how many thousands of animals in France have suffered from penetrating wounds of the feet due to nails picked up on the road. Fortunately, all such cases do not terminate in lock-jaw, but the inefficiency resulting from this class of injury has been so great that in France public notices have been erected urging that nails should not be thrown about. Many contrivances have been adapted to the feet, with more or less success, to prevent injury when a nail is trodden upon, and a form of electric road-sweeper has been devised which will pick up nails, on the principle of the magnet.

Lock-jaw frequently follows gun-shot wounds; especially has this been the case during the present campaign in France. The infection comes from the soil, particularly that which has been highly manured. An animal may be protected against this disease if a special antidote—prepared from the organism which produces the disease—be injected under the skin very early after the infliction of the injury, and tens of thousands of these doses have been given to horses during the present war.

A peculiar but well-known eruption on the tongue and mouth has proved at times a serious source of inefficiency during the campaign. The disease has a long name, which I will not inflict on you. A far more important matter is the extreme contagiousness of the disorder, and the great loss in "condition" which it occasions through the animal being unable to eat.

The last disease I shall refer to is a peculiar form of *Ophthalmia* affecting horses in France, which has resulted in very many cases of blindness. Towards the end of the campaign in South Africa the same disease was present, and occasioned a vast amount of inefficiency. It is no new disorder; its great terror in the field is its incurability and the extraordinary number of animals affected.

I have made no mention of the commoner troubles which fill a veterinary hospital, such as lameness, foot injuries and diseases, kicks, diseases of the organs of digestion and such like, but have focussed your attention on the larger and more serious groups, in order to give you a notion of the kinds of disorders with which veterinary hospitals have to deal in war.

Side by side with improved methods of treating disease, there have been going on during the whole campaign inquiries into the nature of diseases, and the study of their prevention, diagnosis and treatment. There are *Bacteriological Laboratories* in each theatre of operations, which have done valuable work. The subordinate staff of the laboratory in France are nearly all ladies. I trust that one outcome of the war will be the entry of ladies into the veterinary profession, for the smaller animals are especially suited to their care.

The whole of the Mallein employed throughout the Service is made in an army veterinary laboratory, hundreds of thousands of doses being sent out in the course of a year.

I must say a few words regarding the *Equipment* used in the field. Every veterinary officer is provided with a chest, containing, medically and surgically, all that he can possibly require, and up to date in every respect. Most of the drugs are in tablet form, so that no weighing is required; and the instruments, bandages and dressings are of the most approved type. This officers' chest is the outcome of many years' experience and trial, and has proved a great success. When the officer is mounted he is provided with a

leather wallet attached to the saddle, containing an emergency surgical outfit and drugs, all of the latter being hypodermic. Apart from the personal equipment of the veterinary officer, every unit has one or more chests containing dressings and emergency medicines, while the subordinate staff are furnished with a leather wallet containing simple remedies. Hospitals are provided with a complete medical and surgical outfit. I will show you these equipments on the screen.

Veterinary equipment is supplied in the field from an advanced depot of veterinary stores, where all replenishments can be effected; the advanced depots are supplied from base depots, while the base depots are supplied from this country. These operations are on an immense scale, and it is gratifying to add that the supply of stores for overseas has never once failed.

I wish time had permitted me to tell you something of the revolution the Veterinary Service has effected in the *Transport of Animals by Sea.* The horse is a bad sailor, but under skilled management the mortality has been reduced beyond belief. Large numbers of animals have been lost by enemy action at sea, and in this connection I cannot help referring to the captain of the s.s. "Canadian," who refused to leave his sinking vessel as he could not find his dog. He was last seen on the bridge standing at the salute!

I feel the responsibility I have incurred in attempting to present to you so large a subject within the limits of a single paper. I have had to discuss highly important questions in a few words, and through lack of time have omitted much I should have liked to say. I have only attempted to give a bird's-eye view of the subject, and trust I have succeeded in showing that veterinary science—"the Cinderella of the sciences," as it has been aptly described—has done something during the present war to justify its existence.

In conclusion, I would draw your attention to the fact that the comforts of war would not have been available for Army animals, had it not been for the generosity of the British public. I am sure that all of the 1,317,000 patients which passed through the various hospitals during the war, would tender their grateful thanks if they could. I am feebly endeavouring to do so for them.

[The paper concluded with a lantern and a cinematograph exhibition, the latter including two films, one of which showed the operations of the parasite in the skin of the horse and the means taken to eradicate it, and the other illustrating the management of a veterinary hospital of the army in France.]

DISCUSSION.

Major-General L. J. Blenkinsopp, D.S.O., said that he would not detain the meeting very long; he only wished, on behalf of his corps—the Army Veterinary Corps—to thank the R.S.P.C.A. for all that they had done during the war. The Society had enabled the Corps to do that which would otherwise not have been possible, and the money which the fund had collected had been the means, as all present would agree, of saving a vast amount of animal suffering in different parts of the world. As Sir Frederick Smith had explained, the Veterinary Corps had been very hard put to it in the war to find and to train officers and men to carry out such work as he had described. They had had to act in different parts of the world and often under very difficult conditions. The largest number of hospitals, of course, had been with the main army in France, although they had seen that evening on the screen a few photographs of hospitals with the armies in other theatres of operations. In France they had done wonderfully well, although he might add that in the other theatres of operations they had done equally well, and often under very trying climatic conditions. In Mesopotamia they had had to deal with hot weather conditions far in excess, he might say, of any that any army had experienced in previous wars. In the Soudan in the old days they thought that they suffered a great deal from the sun, but it was nothing compared with what the people in Mesopotamia experienced—men who had been in both theatres of operations had told him so. Similarly, in Palestine the armies had suffered greatly from want of water, and the animals had been very seriously affected in that country. Salonica was another place where the army animals had suffered very much from the ticks, whose action had been shown on the screen, and large numbers of the animals had been in hospital suffering from a form of fever, the result of these infecting parasites. In all these theatres they had been helped by the R.S.P.C.A., and also in England, where they had been able to provide those laboratories which had been seen on the screen, and particulars of whose equipment had been brought before them. By means of the work done in these laboratories he was confident that in future years they would be able to save much animal suffering. Much had already been done in this direction in the war, and the work would be progressively useful as officers became better trained and the organisation more complete.

Sir Frederick Smith moved a vote of thanks to the Duke of Portland for occupying the chair, and upon the vote being carried—

The Chairman (His Grace the Duke of Portland) said that it had given him the greatest pleasure to come that afternoon. They had had a most interesting paper which would do a great deal of good and create new interest. He was sure he was only interpreting the wishes of the meeting when he tendered to Sir Frederick Smith their hearty thanks for his paper.

The vote of thanks to Sir Frederick Smith was carried unanimously.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—December 27, 1918.

No. 3450. JANUARY 3, 1919. Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2.

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers over three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2)

Journal of the Royal Society of Arts.

No. 3,450. **VOL. LXVII.**

FRIDAY, JANUARY 3, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 8th, at 3 p.m. (Juvenile Lecture.) Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical Institute, Finsbury, "Liquid Drops and Globules." (Lecture II.)

The lecture will be illustrated with numerous experiments.

Further particulars of the Society's meetings will be found at the end of this number.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s*. each, on application to the Secretary.

JUVENILE LECTURE.

On Wednesday afternoon, January 1st, Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair, Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, delivered the first of his course of Juvenile Lectures on "Liquid Drops and Globules."

The lecturer stated that liquid drops and globules were such common objects that most people were apt to overlook the many interesting facts that might be gleaned from a closer study of this subject. The shape of a drop is due to the condition of the surface, which is in a state of tension, and possesses the properties of an elastic skin. Were it not for gravitation, all liquid drops would be spherical in shape, like a soap-bubble, but they are usually distorted by their own weight. When a drop of liquid is formed in a medium of the same density, thereby losing its weight, its shape is then spherical, and this was illustrated by running orthotoluidine into water at 20° C. The tendency of detached masses of liquid to assume a spherical shape owing to surface tension was shown by experiments with threads of golden syrup, condensed milk, and glycerine; and by rotating a bulb containing water and a quantity of aniline, which caused the latter liquid to break up into spheres of varying sizes. The phenomena attendant upon the breaking away of drops from the end of a tube in air cannot be observed by the eye, owing to the rapidity of the action, but by allowing the drop to form and fall in another liquid almost as dense, all the details may be observed at leisure. Thus by forming drops of orthotoluidine in water at 15° C., the varying shapes assumed by the hanging drop, the drawing-out of the neck prior to partition, and the formation of a droplet from the neck were plainly seen. The effect of temperature on the density of liquids was shown by forming drops of aniline in cold and hot water respectively, the aniline sinking in the former and rising in the latter. This fact explains the behaviour of aniline in hot water, on the surface of which it floats until slightly cooled, when a drop detaches and sinks, but rises again when warmed by the water below, large falling drops being thus formed automatically.

Other experiments shown were the formation of water drops covered by skins of other liquids, some of which dive down into water; the making of stable columns of liquids; the production of combined liquid and vapour drops; and a simple form of spinning-top which owed its rotation to surface tension.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PHYSICAL CHEMISTRY AND ITS BEARING ON THE CHEMICAL AND ALLIED INDUSTRIES.

By Professor James C. Philip, O.B.E., M.A., Ph.D., D.Sc.

Lecture I.—Delivered December 2nd, 1918.

The field of physical chemistry, although now fully recognised as an integral part of chemical knowledge, has sometimes been regarded as lying entirely apart from that of industrial activity. This is a complete misconception, for while the influence of physical chemistry on the conduct of technical processes in the chemical and allied industries is, no doubt, indirect in the majority of cases, it is none the less real and extensive. Physical chemistry is concerned mainly with general underlying principles, but its development has contributed in a notable degree to the further advancement of chemical knowledge from the purely descriptive to the rational and quantitative stage. This is abundantly evident in the recent history of inorganic chemistry. Important reactions between well-known substances, reactions which twenty or thirty years ago were well understood in a general way, have been explored afresh in the light of physico-chemical principles, and an enormous amount of valuable quantitative data has been accumulated in this renascence of inorganic chemistry.

In the chemical and allied industries, as elsewhere, one main element in progress and development is the gradual substitution of quantitative knowledge for qualitative, and the displacement of rule-of-thumb, haphazard methods by those which are based on scientific principles, and therefore permit intelligent control. In the advance so far made along these lines physical chemistry has played no small part, and it is the object of these lectures to emphasise and illustrate some of the physico-chemical principles which have a definite bearing on industrial processes.

One of the main directions in which physical chemistry has led to a clearer perception of the optimum conditions and the working limits of technical operations is in connection with chemical equilibrium. Up till a comparatively recent time the best known chemical reactions were of the type which may be described as "complete" in the sense that the change proceeds until one at least of the necessary reacting compounds has been used up and has disappeared. This, perhaps, is not surprising, for the object of analytical chemistry—one of the prominent practical branches of the science—is to discover precisely those reactions which are complete, involving the quantitative conversion of some one substance into another. It is on the quantitative character of the change that the possibility of accurate analysis depends.

Physical chemists, however, have directed attention specially to those numerous reactions which may be described as "incomplete," in that the change stops short of the entire disappearance of any one of the reacting substances, and all the parties to the reaction are represented in the mixture finally obtained. A state of balance or equilibrium between the various substances concerned is established, and the reaction is accordingly termed an "equilibrium" or "balanced" reaction. In such cases it is further found that if the reaction products, or the "resultants," as they may be called, are brought together, they also interact to produce the original substances. The reaction, that is, may proceed in either direction, according to the relative proportions of the compounds concerned, and it may therefore be fairly described as a "reversible" reaction. It is customary to indicate the existence of this reversibility in any particular case by the use of a double arrow instead of the sign of equality, thus: $A + B \rightleftarrows C + D$.

The further question now arises as to the factors which determine the position of the equilibrium in a reversible reaction, and to this question physical chemistry can supply a quantitative answer. Suppose, for instance, that the substances A, B, C, and D in the foregoing reaction are gases. Then, in accordance with the kinetic conception of the gaseous state, one must picture the molecules in a mixture of the four substances as in a constant state of motion, continually colliding with one another and impinging on the walls of the containing vessel.

Now chemical action between A and B will be possible only when a molecule of A collides with a molecule of B, and the progress of the change denoted by the upper arrow will depend on the number of these collisions occurring per unit of time—*i.e.* on their frequency. The frequency of collision, on the other hand, will be proportional to the numbers of the molecules of the substances A and B which are present in unit volume—*i.e.* to their concentrations. Hence,

if the change is resolved into two component opposed reactions $A + B \rightarrow C + D$ and $C + D \rightarrow A + B$, and if v_1 denotes the velocity of the former reaction and v_2 that of the second, then $v_1 = k_1ab$, and $v_2 = k_2cd$, where a, b, c, d are the concentrations of the four molecular species A, B, C and D at the moment considered, and k_1, k_2 are proportionality factors. These formulæ are the algebraic expression of the law of mass action.

For an observer it is not possible to isolate and follow the separate component velocities: he can determine only the net velocity of the total change—*i.e.* $v_1 - v_2$. As the reaction approaches its position of equilibrium, $v_1 - v_2$ becomes smaller and smaller, and, finally, when equilibrium is established, $v_1 - v_2 = 0$. This does not mean that the reaction mixture is in a condition of stagnation, that all collisions and interchanges have ceased; it means only that there is as much change in the one direction as in the other.

At equilibrium, then, $v_1 = v_2$ or $k_1ab = k_2cd$, a, b, c, and d being now the concentrations of A, B, C, and D in the equilibrium mixture. This equation may be written $k_1/k_2 = cd/ab$, or, since the ratio of two constants is itself a constant, $K = \frac{cd}{ab}$. This quantity K is termed the "equilibrium constant" of the reaction, and its numerical value defines the position of equilibrium for $A + B \rightleftarrows C + D$ at the temperature considered. This argument may be generalised, and the law of mass action leads to the conclusion that, however the individual concentration values may vary, $\frac{Y}{X}$ = const. at any given temperature, where X is the product of the equilibrium concentrations of the substances on the left-hand side of the equation, and Y is the product of the equilibrium concentrations of the substances on the right-hand side.

These considerations may be applied in the first case to the well-known and technically important equilibrium between sulphur dioxide, oxygen, and sulphur trioxide. This may be represented as $2SO_2 + O_2 \rightleftarrows 2SO_3$, and is the reaction utilised in the large-scale production of sulphuric acid by the so-called contact process. It has long been known that sulphur dioxide and oxygen, if passed together over heated platinum, combine to a large extent to form sulphur trioxide, and, indeed, an English patent for such a process was taken out in 1831. Many decades passed, however, before the process was satisfactorily established on the manufacturing scale, the delay being mainly due to difficulties experienced in purifying the sulphur dioxide and in keeping the platinum in full activity as an accelerator of the change.

In the last few years this contact process for the manufacture of sulphuric acid, previously exploited mainly in Germany, has undergone a rapid development in this country, and large quantities of "oleum," essential for the production of explosives, have been turned out. Sulphuric acid, however, is in large demand also in the times of peace, and it may be hoped that the various contact plants laid down under the pressure of war conditions will have a role to play when things are normal once again.

The possibilities and limitations of the contact process for sulphuric acid production cannot be thoroughly appreciated except on the basis of the principles of chemical equilibrium. These principles make it possible to formulate definitely the extent to which the equilibrium will be affected by varying the quantities of the reacting substances, and by altering the pressure and the temperature.

In the first place, the law of mass action may be applied, on the lines already indicated, to the reversible reaction $2SO_2 + O_2 \rightleftarrows 2SO_3$, or, as it may be written alternatively, $2SO_3 \rightleftarrows 2SO_2 + O_2$. If c_{SO_3}, c_{SO_2} and c_{O_2} represent the concentrations of sulphur trioxide, sulphur dioxide and oxygen at the point of equilibrium, then $\frac{c^2_{SO_2} \cdot c_{O_2}}{c^2_{SO_3}} = K$, the value of which should be constant at a given temperature, irrespective of variations in the relative quantities of sulphur dioxide and oxygen initially used.

The validity of the foregoing mass action formula has been strikingly verified by an investigation in which mixtures of sulphur dioxide, oxygen, and nitrogen in varying proportions were passed through heated quartz vessels containing spongy platinum. The rate of flow was regulated so that the gases were long enough in contact with the hot platinum to attain the condition of equilibrium, and the values of c_{SO_3}, c_{SO_2} and c_{O_2}, the equilibrium concentrations, were deduced from a chemical analysis of the issuing gas mixture. Some results obtained at 727° may be quoted in order to show how closely the mass action formula represents the actual composition of the equilibrium mixture. In the following table, which embodies these results, the first three columns state the relative proportions of the gases (sulphur dioxide, oxygen, and, in some

cases, nitrogen, present in the initial mixture employed in each experiment:—

$$2SO_3 \rightleftarrows 2SO_2 + O_2 \text{ at } 727^\circ.$$

Initial Gas Ratio.

SO_2	O_2	N_2	$K \times 10^3$
0·21	1	0	3·49
0·62	1	0	3·59
1·20	1	0	3·48
1·68	1	0	3·51
3·97	1	0	3·67
1·23	1	3·76	3·60
1·31	1	3·76	3·54
1·55	1	3·76	3·52
		Mean	3·55

As shown clearly by these figures, the value of K is independent (1) of the relative proportions of sulphur dioxide and oxygen in the initial gas mixture, and (2) of the presence or absence of nitrogen. In the course of the experiments it was further shown that the value of K obtained with a particular gas mixture was independent of the direction in which the equilibrium point was reached, and of the rate at which the gas was passed. It appears, therefore, that the mean value of K above may fairly be taken as a quantitative expression of the relation which at 727° exists between the equilibrium concentrations of the various substances concerned in the reaction.

When similar investigations are made at a series of different temperatures, the values of K are found to exhibit a regular increase with rise of temperature, and thus form a record of the way in which the equilibrium shifts as the temperature conditions alter. The following table embodies the results of such experiments carried out at various points between 528° and 897° C.:—

$$2SO_3 \rightleftarrows 2SO_2 + O_2 \text{ at Different Temperatures.}$$

Temp. C.	$K \times 10^3$
528°	0·015
579°	0·077
627°	0·32
680°	1·12
727°	3·55
789°	12·6
832°	28·0
897°	81·6

If it is borne in mind that $K = \frac{c^2_{SO_2} \cdot c_{O_2}}{c^2_{SO_3}}$, the increase of K revealed by the foregoing figures plainly means that with rising temperature the equilibrium is shifted more and more in favour of the system $2SO_2+O_2$, *i.e.* the dissociation of sulphur trioxide steadily increases.

From the values of K just tabulated it is easy to trace a graph representing the relation between K and the temperature, and from this to read off the value of the equilibrium constant at any desired point, such as 500° or 600°. The numerical value of K at this point being known, it is then possible to calculate for any initial mixture of sulphur dioxide, oxygen and nitrogen, what will be the composition of the equilibrium mixture, that is, to evaluate the maximum quantity—the "yield"—of sulphur trioxide obtainable under the given conditions. A series of such figures (see following table) shows clearly what are the optimum conditions—so far as the influence of temperature on yield is concerned—for the production of sulphuric acid by the contact process:—

Percentage Composition of the Initial Gaseous Mixture.			Percentage Conversion of Sulphur Dioxide to Trioxide at			
SO_2	O_2	N_2	400°	500°	600°	700°
10·1	5·05	84·85	96·2	83·2	59·1	31·9
7·0	10·0	83·0	99·3	93·4	73·3	42·5
4·0	14·6	81·4	99·4	94·9	78·3	48·1
2·0	18·0	80·0	99·5	95·6	80·5	51·3

The figures just presented furnish the material for testing an interesting deduction that may be drawn from the equilibrium formula. If this is written in the form

$$\frac{c^2_{SO_3}}{c^2_{SO_2}} = \frac{1}{K} \cdot c_{O_2} \quad \text{or} \quad \frac{c_{SO_3}}{c_{SO_2}} = \frac{1}{\sqrt{K}} \cdot \sqrt{c_{O_2}},$$

it is plain that the proportion of trioxide to dioxide in the equilibrium mixture, at a given temperature, is proportional to the square root of the oxygen concentration, and will therefore rise as the latter is increased. This conclusion is confirmed by the figures in the table, for it is seen that, as the percentage of oxygen in the initial mixture increases relatively to that of the sulphur dioxide, the percentage conversion goes up.

The very marked falling off in the yield of sulphur trioxide with rising temperature is in harmony with the well known physico-chemical principle associated with the name of Le Chatelier, viz., that if any change in the external conditions (pressure and temperature) is imposed on any system in equilibrium, then the equilibrium shifts in such a direction as to meet and partially neutralise the change in question.

If, for example, the temperature of a closed

vessel containing only water and water vapour is raised, some of the water will evaporate, until the vapour pressure has risen to the value appropriate to the higher temperature. Evaporation, however, is accompanied by absorption of heat, and the equilibrium between water and water vapour shifts therefore with rise of temperature in that direction which involves a partial neutralisation of the heat communicated from the outside.

So with any reversible chemical reaction, if the temperature of the equilibrium mixture is raised, the position of equilibrium shifts in that direction which involves absorption of heat. Now, the formation of sulphur trioxide from sulphur dioxide and oxygen is an exothermic process, *i.e.* the change $2SO_2 + O_2 = 2SO_3$ is accompanied by the evolution of heat, and it therefore follows that the reverse process—the dissociation of the trioxide—involves absorption of heat. Rise of temperature accordingly favours the formation of the system sulphur dioxide + oxygen at the expense of the sulphur trioxide.

The influence of temperature on the equilibrium constant K of a reaction, and its relation to the heat effect of the reaction is expressed in the thermodynamic equation—

$$\frac{d(\log_e K)}{dT} = -\frac{Q}{RT^2},$$

where Q is the quantity of heat liberated when the reaction goes completely from left to right at the absolute temperature T, and R is the well-known gas constant. It appears that the value of Q for the reaction $2SO_3 = 2SO_2 + O_2$ is a linear function of the temperature, and may be represented by the equation $Q = -47{,}300 + 4T$. If this value of Q is put in the foregoing thermodynamic equation, and the latter is then integrated, a formula is obtained which expresses the variation of K with the temperature, viz.:—

$$\log_{10} K = -\frac{10373}{T} - 2{\cdot}222 \log_{10} T + 14{\cdot}585.$$

The values of K given by this equation are in close agreement with the experimental figures.

The Le Chatelier principle referred to above makes it possible to predict the effect of increasing the pressure on any equilibrium system at constant temperature. If, for example, ice and liquid water are in equilibrium at 0° C., and a bigger pressure is applied, the system meets this by shrinking, *i.e.* the equilibrium shifts so as to increase the proportion of the denser constituent (liquid water) at the expense of the lighter (ice). Similarly, with any reversible chemical reaction at a given temperature, increase of pressure favours the formation of the system occupying the smaller volume, and the equilibrium accordingly shifts in that sense.

In the equilibrium represented by $2SO_3 \rightleftarrows 2SO_2 + O_2$, the number of molecules on the left being two, that on the right three, it is clear that the sulphur trioxide occupies a smaller volume than the sulphur dioxide and oxygen from which it is formed. Hence increase of pressure at any temperature would lead to a greater percentage conversion of the dioxide into the trioxide. If the maximum yield of sulphur trioxide obtainable at the ordinary pressure and at all temperatures within the possible working range were comparatively low, then it might be desirable, even on the manufacturing scale, to carry out the contact process under pressure. Since, however, that contingency does not arise, the question of operating under pressure does not present itself in any practically urgent shape.

The law of mass action, then, coupled with the principles of thermodynamics, leads to a complete quantitative presentation of the equilibrium between sulphur trioxide, sulphur dioxide and oxygen, as it exists over a fairly wide range of temperature, and if the yield were the only factor to be considered in the contact process, it is plain that the lower the working temperature the better. The manufacturer, however, has to take another factor into account, and that is the time required at each temperature for the establishment of the equilibrium. The velocity of chemical reactions, as shown by innumerable physico-chemical investigations, has a very big temperature coefficient, and as a rule is doubled or trebled for a rise of 10° C. The contact process is no exception to this rule, and the rate at which sulphur dioxide and oxygen combine to form sulphur trioxide in presence of a catalyst increases very rapidly with rising temperature.

The practical question is whether, at those temperatures for which the yield approaches 100 per cent., the reaction proceeds to equilibrium in a reasonably short time. Clearly the manufacturer might prefer a somewhat lower yield of the trioxide, combined with a greater rate of reaction, than an almost quantitative yield with a slow reaction and the extra costs which this would involve. Such a question must manifestly be decided in favour of those working conditions which give the best economic return.

Fortunately, in the case of the contact process, it is possible to operate with satisfactory speed even at temperatures as low as 400–500°, where the percentage yield is still very high. This

possibility is due to the fact that platinum, in one form or another, is such an efficient catalyst of the reaction between sulphur dioxide and oxygen. Other and less efficient catalysts, such as the ferric oxide obtained by roasting pyrites, can be and are employed, but the establishment of equilibrium at 400–500° in such cases would be a very slow and uneconomical process. When ferric oxide is used as catalyst in the contact process, the balance between yield and rate of change is struck by working at about 600°. Not until this temperature is reached does the reaction in presence of ferric oxide become reasonably rapid. The yield under these conditions goes down to 60–70 per cent., but against this may be put the fact that this is achieved by the use of a cheap contact substance. When ferric oxide is used as the catalyst, as in the Mannheim process, the unchanged sulphur dioxide may, after removal of the trioxide by absorption, be passed into a second converter in which a platinum catalyst is employed.

Another important technical gas reaction which is of peculiar interest from the standpoint of these lectures, and has been of great significance in connection with the war, is the synthesis of ammonia from nitrogen and hydrogen. In the case of the sulphuric acid contact process, the technical development was largely independent of and anterior to the application of physico-chemical principles, however valuable these may now be in formulating the influence of varying conditions and in giving quantitative expression to the possibilities of the process. In the synthesis of ammonia, on the other hand, the physico-chemical investigation came first, and the large-scale process now operated is the direct outcome and development of work carried out on purely scientific lines.

It has long been known that when electric sparks are passed through ammonia gas for some time, it splits up into the constituent elements, but Deville pointed out about fifty years ago that even after prolonged sparking there was still a trace of ammonia left, as was proved by the faint white cloud formed when a little hydrogen chloride gas was mixed with the decomposition products. Deville further succeeded in showing that a minute quantity of ammonia is produced when a mixture of nitrogen and hydrogen is passed through a heated tube.

The real recognition of the decomposition of ammonia as a reversible reaction came, however, much later, and the application of the principles of chemical equilibrium to this case belongs to quite a recent period. In 1905 Haber showed that if ammonia is passed over finely divided iron at a high temperature (about 1000° C.), a small quantity of the gas escapes decomposition; and, further, if the residual nitrogen and hydrogen, now freed from ammonia, is passed over finely divided iron at the same temperature as before, fresh ammonia is generated, the quantity being practically equal to that which escaped decomposition in the first instance. It is clear, therefore, that the reaction is a reversible one, and may accordingly be written $N_2+3H_2 \rightleftarrows 2NH_3$, although there is no doubt that at 1000° C. and the ordinary pressure the equilibrium position lies almost at the system represented by the left-hand side of this equation.

It is instructive and, as it turns out, of the highest practical significance, to study the influence of changing pressure and temperature on the ammonia equilibrium. In this investigation Le Chatelier's principle is again a trustworthy guide. It has already been stated that in any reversible chemical reaction which has reached equilibrium an increase of pressure at constant temperature favours the formation of the system occupying the smaller volume, and shifts the equilibrium in that sense. The application of this theorem to the ammonia equilibrium $N_2 + 3H_2 \rightleftarrows 2NH_3$, leads to the conclusion that the equilibrium mixture at any temperature will contain a greater proportion of ammonia when the pressure is high than when it is low. If the object is to produce ammonia by the union of hydrogen and nitrogen, then the yield will be increased by working under high pressures.

A more definite formulation of this pressure effect is possible when we turn to the equilibrium constant and express it, not in terms of the equilibrium concentrations of nitrogen, hydrogen, and ammonia, but in terms of their equilibrium partial pressures, p_{N_2}, p_{H_2} and p_{NH_3}. On this basis $\frac{p^2_{NH_3}}{p_{N_2} \cdot p^3_{H_2}}$ = const. at a given temperature, or alternatively, $K = \frac{p_{NH_3}}{p^{\frac{1}{2}}_{N_2} \cdot p^{\frac{3}{2}}_{H_2}}$.

Now, at high temperatures p_{NH_3} is known to be small compared with p_{N_2} or p_{H_2}, and so long as this condition holds no great error is involved in writing $p_{N_2} + p_{H_2} = P$, where P is the total pressure of the three gases. Further, where the nitrogen and hydrogen have been taken in the volume proportion 1 : 3, $p_{H_2} = 3p_{N_2}$. When

these relationships are coupled with the equation for the equilibrium constant, it follows that $p_{NH_3} = 0·325K \times P^2$—that is, the partial pressure of the ammonia in the equilibrium mixture is, for low concentrations of ammonia, proportional to the *square* of the total pressure.

The percentage of ammonia by volume (x) in the equilibrium mixture will be given by $x = \frac{p_{NH_3}}{P} \times 100 = 0·325 \text{ K} \times \text{P}$, and it is therefore to be expected that x will increase approximately in proportion to the total pressure of the reaction mixture. This prediction is confirmed by experiments in which Haber showed, for example, that the volume percentage of ammonia in the equilibrium mixture at 800° and a pressure of one atmosphere was about 0·012, whereas under a pressure of thirty atmospheres at the same temperature the percentage was 0·34, *i.e.* nearly thirty times as great.

The approximate proportionality between the volume percentage of ammonia in the equilibrium mixture and the total pressure is further emphasised by the figures on page 100 (Haber), which show the exactly calculated influence of high pressures on the position of equilibrium at different temperatures. It will be observed, on reference to these figures, that the proportionality between the percentage of ammonia and the pressure is most exact where the values of the former are low. Where these values become appreciable their increase is somewhat less than proportional to the rise of pressure.

At an early stage in the experimental investigation it was recognised that a rise of temperature was inimical to the conversion of nitrogen and hydrogen into ammonia, but this is only what could be foreseen on the basis of Le Chatelier's theorem. For the combination of nitrogen and hydrogen to form ammonia is accompanied by the evolution of heat, and since rise of temperature invariably shifts an equilibrium in the direction which involves absorption of heat, it follows that the percentage of ammonia obtainable from the two gases diminishes as the temperature rises.

This may be put more definitely with the help of the thermodynamic equation $\frac{d(\log_e K)}{dT} = -\frac{Q}{RT^2}$, already quoted in connection with the sulphur trioxide equilibrium. If the relation between specific heat and temperature is known for each of the gases concerned in a gaseous reaction, the variation of the heat effect Q can be formulated; for, according to Kirchhoff's theorem, $\frac{dQ}{dt} = C_1 - C_2$, where C_1 is the sum of the molecular specific heats of the reacting substances at constant pressure, and C_2 is the corresponding quantity for the resulting products. In the case of the ammonia reaction C_1 is the true specific heat at constant pressure of a mixture of ½ gram molecule of nitrogen + $\frac{3}{2}$ gram molecule of hydrogen, and has been found to be $13·47 + ·00164\ t$, where t is temperature Centigrade. The quantity C_2, on the other hand, is the true specific heat at constant pressure for 1 gram molecule of ammonia, and is given by the equation $C_2 = 8·62 + ·0035\ t + 5·1 \times 10^{-6}\ t^2$. If these expressions are inserted in the Kirchhoff formula $\frac{dQ}{dt} = C_1 - C_2$, and this is integrated, then $Q = Q_0 + 4·85\ t - ·00093\ t^2 - 1·7 \times 10^{-6}\ t^3$ gram calories. The constant Q_0 represents the heat evolved in the reaction $\frac{1}{2}(N_2 + 3H_2) = NH_3$ at 0°C., and has been found to be 10950 cal., so that the heat effect of the foregoing reaction at t° C is given by $Q = 10950 + 4·85\ t - ·00093\ t^2 - 1·7 \times 10^{-6} t^3$. If this expression for the heat of reaction is put in the equation $\frac{d(\log_e K)}{dT} = -\frac{Q}{RT^2}$, and the latter is then integrated, a formula is finally obtained which represents the equilibrium constant of the ammonia reaction as a function of temperature. The formula so found by Haber is $\log_{10} K = \frac{2098}{T} - 2·5088 \log_{10} T - 0·0001006\ T + 0·186 \times 10^{-6}\ T^2 + 2·1$. The values of K calculated in this way are in remarkably good agreement with the experimental determinations of the ammonia equilibrium, as is shown, for example, by the measurements made at thirty atmospheres pressure and various temperatures:—

t°C.	$K \times 10^4$ found.	$K \times 10^4$ calc.
561°	21·3	21·5
620°	12·6	12·7
700°	6·80	6·88
722°	5·82	5·92
801°	3·56	3·60
901°	2·13	2·11
952°	1·68	1·66

The validity of the foregoing equation being thus established, it may be employed to calculate for even temperatures and a number of pressures the maximum quantities of ammonia obtainable by the interaction of nitrogen and hydrogen. These figures, constituting a summary of the influence of temperature and pressure on

the ammonia equilibrium, are presented in the following table [valid for 1 vol. nitrogen + 3 vols. hydrogen]:—

Temp. Cent.	Equilibrium Percentage of Ammonia at 1 atmo.	at 30 atmos.	at 100 atmos.	at 200 atmos.
200°	15·3	67·6	80·6	85·8
300°	2·2	31·8	52·1	62·8
400°	0·44	10·7	25·1	36·3
500°	0·129	3·62	10·4	17·6
600°	0·049	1·43	4·47	8·25
700°	0·022	0·66	2·14	4·11
800°	0.012	0·35	1·15	2·24
900°	0·0039	0·21	0·68	1·34
1000°	0·0044	0·13	0·44	0·87

From the physico-chemical standpoint then, the conditions which affect the position of the ammonia equilibrium are thoroughly understood, and their influence can be definitely formulated. Plainly, the highest percentage conversion of nitrogen and hydrogen into ammonia is to be secured by working at a high pressure and a low temperature. There is, however, a limit to the pressure under which a large scale process can be carried out conveniently and safely, and the pressure employed in practice is not above 150–200 atmospheres. The use of high pressures such as those just quoted leads not only to a favourable displacement of the equilibrium, but also to an increased rate of approach to the equilibrium position.

A limit is set also to the reduction of temperature, which from the point of view of yield alone is desirable, by the difficulty of finding catalysts which are sufficiently active below 500°–600° C. From the point of view of technical production, the rate at which the reaction takes place is naturally of prime importance, and this comes back really to the question of the activity of the catalyst employed.

Of itself, the reaction $N_2 + 3H = 2NH_3$ takes takes place very slowly at temperatures below 1000°, and it is only in the presence of catalysts such as osmium, uranium, and iron, that the formation of ammonia becomes reasonably rapid at temperatures where the yield is still moderately satisfactory. In the manufacturing process, a mixture of nitrogen and hydrogen at a pressure of 150–200 atmospheres is passed over the catalyst at a temperature of 500–600° C., the small quantity of ammonia formed is removed by refrigeration or absorption, and the residual gases are again circulated over the catalyst. High yield and rapid establishment of equilibrium are not reconcilable, and a balance has to be struck at the temperature which gives the best economic results.

In working out the most satisfactory conditions for the technical synthesis, another factor has to be considered, and that is the rate of circulation of the gases over the catalyst. If this rate is high the percentage of ammonia formed per passage will fall a good deal short of the equilibrium percentage, but, on the other hand, there will be all the more passages in a given time. It has indeed been shown by Maxted that for a catalyst chamber of given size, the highest yield of ammonia per hour is obtained with a very high rate of circulation and a minimum value for the percentage of ammonia formed per passage. This is made clear by the following record, obtained with an iron-potash catalyst at 550° C. and 150 atmospheres:—

Time of contact of gas with catalyst in seconds.	Per cent. ammonia formed.	Yield of ammonia in kilos per hour per litre of catalyst space.
0·34	0·65	2·7
0·56	0·94	2·3
1·8	1·8	1·4
3·6	3·2	1·25
7·2	4·7	0·91

From recent information, for which the writer is indebted to Mr. Maxted, it appears that with a somewhat more active iron catalyst and extremely rapid circulation, yields of ammonia up to 10 kilos per hour per litre of catalyst space may be obtained. There are, however, difficulties in the construction of satisfactory heat exchangers for the commercial utilisation of such rapid circulation. The optimum rate of circulation must be determined for each plant.

The fact that in actual working, where a moderately high rate of circulation is employed, the percentage of ammonia does not reach the equilibrium value, involves the possibility that a rise of temperature may even lead to an increase in the yield of ammonia per passage. This has been found to occur in some experiments carried out by Maxted at 530° and 580° C.

Catalyst—Iron Potash. Pressure—150 atmos.

Time of contact in seconds.	Percentage of ammonia formed at 530°.	at 580°.
0·6	0·96	1·5
1·0	1·3	2·4
1·5	1·7	3·2
2·0	2·05	3·8

Such an increase in the yield accompanying a rise of temperature can occur only when the

yield is much less than the maximum obtainable—*i.e.* the equilibrium value. At a higher range of temperatures, where the establishment of equilibrium is very rapid, a rise of temperature will lead to a decrease, not an increase, of the ammonia yield.

It has been shown above that the displacement of the ammonia equilibrium with rise of temperature is represented by the equation:— $\log_{10} K = \frac{2098}{T} - 2{\cdot}5038 \log_{10} T - 0{\cdot}0001003\, T + 0{\cdot}186 \times 10^{-6}\, T^2 + 2{\cdot}1$, and the values of K given by this formula are in good agreement with the figures obtained experimentally up to 1000° C. If the validity of the formula is assumed for still higher temperatures, it follows, as shown by Maxted, that the decrease of K with rising temperature continues up to a point about 2500° abs., but that a further rise of temperature should be accompanied by an increase of K. The approximate position of the minimum value of K appears from the following calculated figures:—

T° abs.	$K \times 10^4$
1500	0·63
2000	0·26
2500	0·21
3000	0·28
3500	0·55

It should be noted that where the displacement of equilibrium with rising temperature is reversed, the heat effect of the reaction must pass through a zero value. This follows from the thermodynamic equation—

$$\frac{d(\log_e K)}{dT} = -\frac{Q}{RT^2}.$$

The prediction of an increased yield of ammonia at extremely high temperatures, a prediction based, it must be admitted, on a very extensive extrapolation of the formula for K, has been verified by Maxted's experiments. In these a mixture of nitrogen and hydrogen was introduced into an oxy-hydrogen flame, and then cooled with extreme rapidity to the ordinary temperature. The gas was then found to contain appreciable quantities of ammonia, estimated in one case to be equivalent to 1·23 per cent. by volume at an absolute pressure of one atmosphere. Rapid cooling is essential, otherwise the equilibrium shifts to the unfavourable position characteristic of the temperatures between 1500° and 3000° abs. The passage of a nitrogen + hydrogen mixture through a capillary tube in which a small high-tension arc is burning leads also to the formation of appreciable quantities of ammonia. It will be interesting to see whether this thermal synthesis of the gas can be effected on anything else than the very small scale which has so far proved practicable.

The catalytic synthesis of ammonia at moderate temperatures, on the other hand, has come rapidly to the front, and has played no small part in the war technology of Germany, where the process was being developed on the large scale in the period 1912–14. During the war synthetic ammonia was turned out in that country at a rapidly increasing rate, and it is stated that the quantity of ammonium sulphate produced by this method has recently amounted to about half a million tons per annum. The significance of this synthetic ammonia industry lies in the fact that the product can be readily oxidised to nitric acid, which, of course, is the indispensable basis of explosives. The fixation of atmospheric nitrogen, however, will be required to meet the needs of peace also, in respect of nitrogenous fertilisers, and in all probability the catalytic synthesis of ammonia has a future before it independent of the demands of war.

In final illustration of the value of the principles of chemical equilibrium in the rational survey and control of a technical gas reaction, one or two points connected with the water gas reaction $CO_2 + H_2 \rightleftarrows CO + H_2O$ may be discussed. There are an equal number of molecules on the two sides of this equation, and it therefore follows that a shift of the equilibrium involves no change of volume. Hence, in conformity with Le Chatelier's principle already referred to, an alteration of the pressure is without effect on the position of equilibrium.

The equilibrium constant in this case is defined as $K = \frac{c_{CO} \cdot c_{H_2O}}{c_{CO_2} \cdot c_{H_2}}$, where c_{CO}, c_{H_2O}, c_{CO_2} and c_{H_2} are the equilibrium concentrations of the different gases concerned. The reaction being reversible, it is possible to approach the equilibrium from either side, and in the actual investigation of the reaction the value of K was deduced from two sets of experiments: (*a*) those in which mixtures of carbon dioxide and hydrogen were passed through a heated quartz or porcelain tube containing platinum as a catalyst; (*b*) those in which mixtures of carbon monoxide and water vapour were treated similarly. An analysis of the gas mixture issuing from the tube gave the values of the

equilibrium concentrations. As an example of the results obtained under (*a*) the following, recorded at 986° C., may be quoted :—

Percentage Composition of the Initial Mixture—		Percentage Composition of the Equilibrium Mixture—			
CO_2	H_2	CO_2	$CO = H_2O$	H_2	K
10·1	89·9	0·70	9·46	80·38	1·59
30·1	69·9	7·18	23·00	46·82	1·58
49·1	51·9	21·36	27·88	22·88	1·59
60·9	39·1	34·20	26·61	12·58	1·64
70·3	29·7	47·66	22·79	6·76	1·61

Experiments carried out at the same temperature with initial mixtures of carbon monoxide and water vapour gave a mean value of 1·55. The agreement of this number with the average of the figures for K recorded in the table shows that the equilibrium between the four gases, whatever their initial concentrations, is established in conformity with the mass action law.

As regards the shift in the equilibrium with rise of temperature, the direction of the shift can be deduced from the known heat effect of the reaction $CO_2 + H_2 = CO + H_2O$. At the ordinary temperature the occurrence of this reaction from left to right is accompanied by the absorption of about 10,000 calories, and hence a rise of temperature will favour the system $CO + H_2O$ at the expense of the system $CO_2 + H_2$. Quantitatively this is shown by the increasing values for K obtained with rising temperature. Thus the figures for the constant at 686°, 786°, 886°, 986°, and 1086°, are 0·53, 0·84, 1·20, 1·57, and 1·96 respectively.

The water gas equilibrium is of interest in relation to the manufacture of hydrogen, the demand for which has steadily increased during the last five or ten years. Apart from its use in connection with airships and balloons, there are various newer industries, in which the gas is required on a large scale, as, for example, in the hardening of fats and in the synthetic ammonia industry. Among other methods for the manufacture of hydrogen in quantity, it has been found possible to make the hydrogen of water available by first producing water gas, and subsequently passing the water gas with excess of steam over a catalyst, such as alkaline ferric oxide, at a temperature of 500–600°. The raising of the concentration of the water vapour must plainly shift the equilibrium in the reversible reaction $CO_2 + H_2 \rightleftarrows CO + H_2O$ over towards the left, and in actual practice it is found that the carbon monoxide of the water gas is almost completely converted into carbon dioxide by this treatment, and that there is a corresponding increase in the quantity of hydrogen. Thus, in one case on record, a water gas containing 24 per cent. carbon monoxide was found, after one passage over the catalyst at 500° with excess of steam, to contain only 2 per cent. of this gas. Naturally the carbon dioxide and the residual carbon monoxide must be removed by condensation or absorption if pure hydrogen is required.

INDUSTRIES AFTER THE WAR.

IV.—TEXTILES (*continued from* *p.* 784, Vol. LXVI.).

Lace.

Lace-making seems to have been a fairly prosperous cottage industry in this country before the era of production by machinery. Some Flemish refugees who settled in Bedfordshire in 1626 are said to have introduced the fabrication of pillow lace, which went under the name of *point d'Angleterre.* The beginnings of the mechanical system date from the close of the eighteenth and the opening of the nineteenth century. Apparently the earliest success of the inventors was achieved by modifications of the stocking frame in use at Nottingham. A little later English and French mechanics simultaneously discovered how to obtain the net mesh. In 1803 the Leicestershire farmer's son, John Heathcoat, who, after his retirement from business, was Palmerston's colleague in the representation of Tiverton, patented the first of his well-known inventions—a bobbing net machine—and in 1814 the Leavers devised their process.

The Board of Trade Committee divides the lace and embroidery trades of these isles into five main classes: (1) Leavers laces, used principally for dress and millinery trimmings and in the making-up trade, blouses, skirts, fancy neckwear, etc.; (2) plain nets, cotton and silk; (3) lace curtains; (4) Plauen laces and embroideries; (5) Barmen trimmings.

In cotton lace Nottingham is still pre-eminent, but France has practically killed the silk branch of the English lace trade, and Germany when the war broke out was a formidable competitor with its Plauen laces and Barmen trimmings. The Plauen machines are only German in name, that is to say, they are of Swiss invention, and were not offered to Germany until Nottingham had refused to look at them. The result of this

"unfortunate mistake" is that the Plauen lace and Barmen trimmings of Germany have displaced and replaced our own fancy lace. The Germans, we are told, have specialised upon a type which permits of great variety, and they have followed on from season to season with beautiful and artistic designs. By this means they acquired predominance in the world's markets—our own purchases of German lace and embroidery in 1912 amounted to £1,485,600—which has enabled them to operate on a large scale at a low cost. Hence the Nottingham manufacturers "have seen the bulk orders go to Germany, and have had to be content with taking orders for special lines, or for goods for immediate delivery. This has meant production upon a small scale with its attendant disadvantages." But they are now anxious to make up for lost ground. "We are informed," the Committee says, "that, since the war, the removal of German competition has greatly stimulated the production of Plauen laces in the Nottingham district, and that manufacturers are prepared to extend their plant if they can obtain any security that they will not be exposed to the full blast of German competition after the conclusion of peace. Their contention is that this branch of their trade is in the position of an 'infant industry,' and that it cannot meet unlimited competition until it has become established, has organised itself upon the basis of large production, and so reduced its costs to a minimum." When the Committee wrote its report, there were in Nottingham about 300 machines for producing embroideries and Plauen laces.

In 1907, according to the Census of Production, the number of persons employed in the industry was 36,840, of whom 20,459 were female workers, while the output was in the same year valued at a little over six million pounds sterling. About 80 per cent. of the output was exported, the principal markets being the United States, South America, the Continent and British possessions. Mosquito nets are a not inconsiderable item. For some years previous to the war German competition in these articles was being felt to some extent in the East. In "Leavers laces" France is our only competitor. In lace curtains our exports have become more and more confined to the Empire. A large trade in this "line" with the United States was killed by the McKinley Tariff. It is interesting to learn that the factories established in Ayrshire during the past twenty years now turn out as many lace curtains as does Nottingham itself.

Yarns of cotton, silk (real and artificial), and linen, form the raw material of the industry. Lancashire furnishes practically the whole of the cotton yarn. The sources of supply for the other yarns are: Belfast and Belgium (linen), Italy and France (silk), and United Kingdom (artificial silk). German lace-makers draw, or rather used to draw, a very large proportion of their raw material from Lancashire. It was pointed out to the Committee that if in future such exports to Germany are restricted an expansion of the Nottingham lace trade "is one of the most obvious compensatory markets for Lancashire spinners."

Formerly the British manufacturer had to rely upon Germany as well as Switzerland for embroidery needles, but since the war the manufacture of these articles has been commenced in this country.

Attention is drawn in the report to the "tenement factories" which are peculiar to the British lace trade, and have given rise to a multitude of small makers. These tenement factories are let by the machine owner in "shops" or "standings" at rents inclusive of power and heating. By paying a deposit of, say, £100 per machine to the proprietor and entering into an agreement to pay the balance of the cost over a term of years, the tenant secures a small plant—three machines being the average. In the event of non-payment of instalments or rent the

Group of Countries.	Imports of Lace and Articles thereof.			
	Of cotton.	Wholly of silk.	Of silk mixed with other materials.	Of other materials.
Foreign Countries:—	£	£	£	£
European:—				
Allies	1,144,135	381,240	28,616	734
Enemies	1,120,305	281	16,217	693
Neutrals	25,495	163	44	—
Total European	2,289,935	381,684	44,877	1,427
Extra European:—				
United States	540	2,000	—	—
China	110	—	—	—
Japan	2,016	871	—	—
Total Extra European	2,666	2,871	—	—
Total Foreign Countries	2,292,601	384,555	44,877	1,427

owner is entitled to seize not only the machines but "all other assets of the hirer." The plan is said to be attended by serious drawbacks. The Committee was informed that the system has encouraged "irresponsible production," "excessive competition," and the "frequent breaking of prices during times of bad trade."

Nottingham possesses a well-equipped Art and Technical School. It seems doubtful, however, if full and effective use is made of that institution by an industry "which has everything to gain from artistic and technical training." More than one witness submitted that much of the success attained by German lace-makers is due to the excellence of the German schools, although often the model designs are of French origin. It is suggested that English manufacturers do not sufficiently interest themselves in local technical schools, and that the courses of instruction are for that reason less practical than they might be. "The importance of co-operation between manufacturers and the managing bodies of technical and art schools is obvious, especially in connection with such industries as lace, which depend upon beauty of design and delicacy of execution."

In 1913 we imported "lace and articles thereof" worth £2,723,696, of which all but a comparatively trifling portion came from France and Germany. Cotton lace was imported in about equal quantities from those two countries. France, as will be seen from the table given above, supplied almost the whole of our imports of silk lace.

The witnesses were practically unanimous in demanding drastic measures against enemy lace manufacturers—prohibition for a period after the conclusion of peace and thenceforward heavy duties. There is, the Committee adds, a strong feeling in favour of reciprocal tariff arrangements with France and Switzerland.

OBITUARY.

SIR FREDERICK A. ROBERTSON, K.B.E., LL.D.—Sir Frederick Alexander Robertson died suddenly in London on December 20th in his sixty-fifth year. Son of James R. Robertson and Mary Elizabeth Campbell of Bragleen, Argyllshire, he was educated at King's College, London, and passed the Indian Civil Service Examination in 1874. He went to India in 1876, being posted to the Punjab. Until 1888 he served as a settlement officer, and in 1889 he was appointed Director of Land Records and Agriculture. He continued to fill that position until 1896, when he was transferred to the judicial side. He had been called to the Bar while at home on furlough. In 1902 he was promoted from a divisional judgeship to the Bench of the Punjab Chief Court. He was Vice-Chancellor of the Punjab University in 1909-10. He received the honour of knighthood in 1913, and retired from the Indian Service in the same year. Settling in London he became Lecturer on Hindu and Mohammedan Law to the Council of Legal Education, and he was also Lecturer on Mohammedan Law at the Imperial Institute. He was made a Fellow of his old College in 1915. His Knight Commandership of the British Empire was conferred on January 1st, 1918, in recognition of his services as Chairman of the Central Council of United Alien Relief Societies. The notable success of the Indian Gymkhana Club is largely due to his exertions, and in various other ways he was untiring in his efforts to assist young Indian students who come to this country for education. He joined the Royal Society of Arts in 1913 and was an active and valued member of the Indian Section Committee.

GENERAL NOTES.

VICTORIA AND ALBERT MUSEUM.—The Victoria and Albert Museum has just received from Mr. Aubrey Le Blond the gift of a fine collection of early Corean pottery and porcelain. It is composed for the most part of wares dating from the time of the Kōrai dynasty, which came to an end in 1392. They combine, with an extraordinary beauty of outline and hue, a variety of decorative processes which should commend them to the interest of technical students. The majority are characterised by a celadon-green glaze of various tones, laid over simple incised designs of exquisite draughtsmanship, or inlaid decoration in white and black clay. It is doubtful whether any larger or more important collection of such wares exists in Europe.

INDUSTRIAL FATIGUE.—A Research Board has been appointed by the Department of Scientific and Industrial Research and the Medical Research Committee jointly to consider and investigate the relations of hours of labour and of other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health among the workers. The duty of the Board will be to initiate, organise, and promote by research, grants, or otherwise, investigations in different industries with a view to finding the most favourable hours of labour, spells of work, rest pauses, and other conditions applicable to the various processes according to the nature of the work and its demands on the worker. For these investigations the Board look forward to receiving the help of employers and workmen in the industries which are studied, and in appropriate cases representatives of both will be invited to serve as temporary members of the Board. The Board has been constituted as follows: Professor C. S. Sherrington, Sc.D., F.R.S. (Professor of Physiology, University of Oxford), chairman; E. L. Collis, Esq., M.B. (Director of Welfare and Health, Ministry of Munitions); Sir Walter Fletcher, K.B.E., M.D., F.R.S. (secretary, Medical Research Committee); W. L. Hichens, Esq. (chairman of Messrs. Cammell

Laird and Co., Limited); Edward Hopkinson, Esq., D.Sc. (director of Messrs. Mather and Platt, Manchester); Kenneth Lee, Esq. (director of Messrs. Tootal Broadhurst Lee Company, Limited); T. M. Legge, Esq., C.B.E., M.D. (H.M. Medical Inspector of Factories); Colonel C. S. Myers, M.D., F.R.S. (Director of the Psychological Laboratory, Cambridge); R. H. Bannatyne, Esq. (Assessor representing the Home Office); D. R. Wilson, Esq. (H.M. Inspector of Factories), secretary. The Board will be glad to receive suggestions as to any problems of the kind described. All communications should be addressed to the Secretary, Industrial Fatigue Research Board, 15, Great George Street, Westminster, S.W. (1)

Reconstruction Committees. — Since December 2nd, 1918, states the Ministry of Reconstruction, seven additional interim Industrial Reconstruction Committees have been formed in the following trades: (1) Artificial stone, (2) brass and copper, (3) women's light clothing, (4) lead-mining, (5) lead, (6) zinc and spelter, and (7) sugar refining. There are now twenty-nine of these committees at work, some of which are reaching the stage when they will be convertible into full Joint Industrial Councils.

Pneumatic Riveting.—The best day's work on a shell with pneumatic riveting, says *Marine Engineering*, in comment on information received from one of the principal east coast shipyards of America, is 700 rivets of ⅞-inch diameter, and for handwork under the same conditions, 430. An average day's work is considerably less than this, and may be taken as being 510 rivets with pneumatic riveters against 264 with a hand-squad for work on all parts of one ship.

New Means of Ship Repairing.—The *Engineer* mentions a new means of ship repairing which has been tried with success by Messrs. Hume Bros., of Buenos Ayres. The ship was a wooden vessel of some 200 tons displacement. The wooden ribs had quite rotted away at the bottom, and the repair consisted in casting in armoured concrete ribs between the existing wooden ribs, the ribs being bonded to the skin by coach screws driven partly into the latter. Here and there extra deep concrete ribs with special reinforcement were taken over the inner or false keel. The repair is reported to be quite successful, and as the concrete takes the place of ballast has added nothing to the weight of the vessel.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

January 15.—A. F. Kendrick, Department of Textiles, Victoria and Albert Museum, "English Carpets." Lord Carmichael, G.C.S.I., G.C.I.E., K.C.M.G., will preside.

January 22.—Lieut.-Colonel H. G. Lyons, D.Sc., F.R.S., Acting Director of the Meteorological Office, "Meteorology during and after the War." Sir William Napier Shaw, D.Sc., F.R.S., Meteorological Adviser to the Government, will preside.

January 29.—Frederick William Keeble, C.B.E., M.A., Sc.D., F.R.S., Director of Horticulture, Food Production Department, "Food Production by Intensive Cultivation."

February 5. — Edward Carstensen de Segundo, A.M.I.C.E., M.I.Mech. E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes." Lord Lamington, G.C.M.G., G.C.I.E., will preside.

February 12.—Sir Frank Heath, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

February 19.—John Francis Crowley, D.Sc., A.M.I.E.E., "The Use of Electricity in Agriculture in Germany." Sir John F. C. Snell, M.Inst C.E., will preside.

February 26.—W. L. Hichens (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry."

March 5.—B. D. Porritt, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

March 12.—

March 19.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

Indian Section.

Thursday afternoons, at 4.30 p.m.:—

January 16.—H. Kelway-Bamber, M.V.O. (late Superintendent of Rolling Stock, East Indian Railway), "Coal and Mineral Traffic on the Indian Railways." Sir Charles H. Armstrong, Chairman, Great Indian Peninsula Railway Company, will preside.

February 13.—

March 13.—

April 3.—Brigadier-General Lord Montagu of Beaulieu, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

FEBRUARY 4.—

MARCH 4.—PROFESSOR JOHN CUNNINGHAM McLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

MAY 27.—SIR EDWARD R. DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced:—

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JANUARY 6...Chadwick Public Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m. Mr. A. H. Barker, "Fuel Economy and Health." (Lecture I.)

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 7.30 p.m. 1. Messrs. P. E. Spielmann and H. Wood, "The Estimation of Cyanogen Compounds in Concentrated Ammonia Liquor." 2. Dr. F. B. Thole, "The Estimation of Benzene and Toluene in Petroleum." 3. Mr. A. Philip, "The Estimation of small percentages of Water in Oils."

Geographical Society, Kensington Town Hall, W., 3.30 p.m. (Juvenile Lecture.) Professor L. W. Lyde, "The Cross Roads of Belgium."

Colonial Institute, Central Hall, Westminster, S.W., 3 p.m. (Juvenile Lecture.) Mr. F. R. D. Onslow, "Some British Birds and their Homes."

TUESDAY, JANUARY 7...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture X.)

Rontgen Society, at the ROYAL SOCIETY OF ARTS, John street, Adelphi, W.C., 8.15 p.m. Dr. H. S. Allen, "Electrical Changes produced by Light."

Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lecture.) Professor D'Arcy W. Thompson, "The Fish of the Sea." (Lecture IV.)

WEDNESDAY, JANUARY 8...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Juvenile Lecture.) Mr. C. R. Darling, "Liquid Drops and Molecules." (Lecture II.)

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. L. H. Pomeroy, "Influence of Valve Lift and Combustion Chamber Design on Consumption."

Geological Society, Burlington House, W., 5.30 p.m. Professor P. F. Kendall and Dr. A. Gilligan, "On Wash-outs in Coal Seams, and the Effects of Contemporary Earthquakes."

Aëronautical Society, Central Hall, Westminster, S.W., 3 p.m. (Juvenile Lecture.) Mr. F. Handley Page, "To Constantinople and Back by Aeroplane in War Time."

THURSDAY, JANUARY 9...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture XI.)

British Acetylene and Welding Association, George and Vulture Hotel, St. Michael's-alley, Cornhill, E.C., 8 p.m. Mr. C. Hoddle, "Workshop Appliances for Oxy-Acetylene Work."

Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lecture.) Professor D'Arcy W. Thompson, "The Fish of the Sea." (Lecture V.)

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. M. B. Field, "The Navigational (Magnetic) Compass as an Instrument of Precision."

Historical Society, 22, Russell-square, W.C., 5 p.m. Dr. W. W. Seton, "The Relations of Henry, Cardinal York, with the British Government."

FRIDAY, JANUARY 10...Swiney Lectures, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. T. J. Jehu, "Man and his Ancestry." (Lecture XII.)

Astronomical Society, Burlington House, 5 p.m.

Geographical Society, Kensington Town Hall, W., 3.30 p.m. (Juvenile Lecture.) Mrs S. Routledge, "Three Islands of the Pacific: Juan Fernandez, Easter Island, and Pitcairn."

SATURDAY, JANUARY 11...Royal Institution, Albemarle-street W., 3 p.m. (Juvenile Lecture.) Professor D'Arcy W. Thompson, "The Fish of the Sea." (Lecture VI.)

Correction.—In the report of Professor S. D. Adshead's remarks on Mr. B. Seebohm Rowntree's paper, "Housing after the War," on page 74, column 2, line 33 (*Journal* of December 20th, 1918), for the words "one-fifth of an acre" read "one-fiftieth of an acre."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—January 3, 1919.

No. 3451. JANUARY 10, 1919. Vol. LXVII

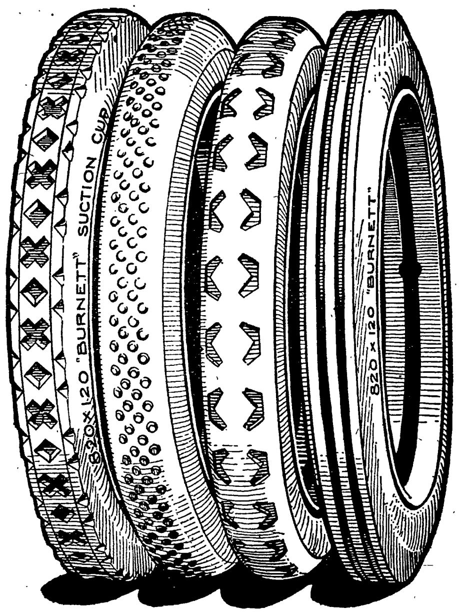
JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2.

REGISTERED AS A NEWSPAPER.


820 x 120 "BURNETT" SUCTION CUP
820 x 120 "BURNETT"

Journal of the Royal Society of Arts.

No. 3,451. VOL. LXVII.

FRIDAY, JANUARY 10, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 15th, at 4.30 p.m. (Ordinary Meeting.) A. F. KENDRICK, Department of Textiles, Victoria and Albert Museum, "English Carpets." SIR WILLIAM M. T. LAWRENCE, Bt., will preside.

THURSDAY, JANUARY 16th, at 4.30 p.m. (Indian Section.) H. KELWAY-BAMBER, M.V.O., M.Inst.Loco.E., late Superintendent, Rolling Stock, East Indian Railway, "Coal and Mineral Traffic on the Indian Railways." SIR CHARLES H. ARMSTRONG, Chairman, Great Indian Peninsula Railway, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

JUVENILE LECTURE.

On Wednesday afternoon, January 8th, Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair, Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, delivered the second and final lecture of his course on "Liquid Drops and Globules."

In continuation of the study of drops, the lecturer showed that when a liquid is allowed to fall on a very hot plate it forms into drops which do not make contact with the heated surface, but float on a cushion of their own vapour and slowly evaporate. On cooling the surface a point is reached at which the drops touch and spread over the plate, when the liquid boils away immediately. Liquids floating above a hot surface are said to be in the "spheroidal state," and the globule acquires a crinkled edge and rotates on its axis.

Mists, fogs, and rain were explained as being due to the condensation of moisture in the form of spheres round a nucleus of solid matter. These spheres, in the case of mists and fogs, are so small as to remain suspended in the air, but on growing larger they fall as rain. The formation of a mist was shown by cooling moist air in a large flask, when a thick mist was produced.

The remaining part of the lecture was devoted to experiments on globules floating on a liquid surface. It was shown that when a quantity of oil is placed on water it spreads out, being stretched by the superior surface tension of the water. A floating globule, when at rest, is under the influence of three tensions, acting in different directions, and if any of these forces be disturbed the shape of the globule is changed. This was shown by allowing a small drop of quinoline to sink through a globule of oil floating on water, which was shattered into fragments the moment the quinoline reached the junction of the oil and water. Certain liquids, when placed on water, are drawn out into films which afterwards break up into globules, the process showing patterns resembling a jig-saw puzzle. This phenomenon was demonstrated by the use of dimethyl aniline and nitrobenzene. A number of liquids, when placed on a water surface, break into globules which move about with remarkable vigour, imitating the movements of some of the lower forms of life, as was demonstrated by using orthotoluidine and xylidine. A further resemblance to living organisms was shown by floating a large globule of dimethyl aniline on a water surface upon which orthotoluidine globules had previously been formed, when the large globule proceeded to engulf all the smaller ones, the action resembling that of the white corpuscles of the blood when absorbing microbes. The lecturer concluded by stating that the study of drops and globules threw much light on the life-history of the lower forms of life, and from this standpoint alone was well worthy of serious attention.

On the motion of the Chairman, a vote of thanks was accorded to Mr. Darling for his interesting course.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PHYSICAL CHEMISTRY AND ITS BEARING ON THE CHEMICAL AND ALLIED INDUSTRIES.

By Professor James C. Philip, O.B.E., M.A., Ph.D., D.Sc.

Lecture II.—Delivered December 9th, 1918.

In the first lecture an attempt was made, more especially in connection with sulphuric acid manufacture and the production of synthetic ammonia, to demonstrate the value of certain physico-chemical principles as applied to technology. These principles provide a rational basis for the investigation of processes in which questions of chemical equilibrium are involved; they permit a concise formulation of the influence of various important factors, and render possible a real scientific control of such operations when they reach the manufacturing stage.

Exact knowledge, however, of the equilibrium conditions prevailing in such technical gas reactions as those already considered does not suffice for the practical manufacturer. For obvious economic reasons he must raise a question as to the *velocity* of the particular reaction concerned. However favourable the position of equilibrium may be with regard to the desired product, the reaction is of no value from the technical standpoint, unless the attainment of equilibrium is, or can be made, reasonably rapid.

Now the velocity of a chemical reaction, as is well known, can be increased by raising the temperature, but this may involve, as in the instances of the sulphuric acid contact process and the ammonia synthesis, an undesirable shifting of the equilibrium, and consequently a diminished yield of the product. A high yield and rapid completion of the reaction may not both be realisable along these lines.

In addition, however, to rise of temperature, there is another recognised method of accelerating a chemical reaction, namely, by the use of "catalysts." These are substances the mere presence of which in contact with the reacting system promotes the change and hastens the establishment of equilibrium. Chemical literature has long recorded observations of a general kind relating to the action of catalysts, but a rational study of their influence and their efficiency can be attempted only on physico-chemical lines. In indicating what these lines are, it is desirable to recall the way in which the physical chemist arrives at a quantitative expression for the rate of a chemical reaction.

The application of kinetic conceptions to a reversible gaseous reaction, as discussed in the first lecture, leads to the view that progress towards equilibrium, *i.e.* the net velocity of the change, is determined by the velocities of two opposed component reactions. Thus if $A+B \rightleftarrows C+D$ represents the reversible reaction, v_1 the velocity of the change $A+B \rightarrow C+D$, v_2 that of the change $C+D \rightarrow A+B$, and a, b, c, d the concentrations at the moment of the four molecular species involved, then the net velocity of the reaction is given by $V=v_1-v_2=k_1ab-k_2cd$. If now it is supposed that the reaction begins with A and B alone present in the concentrations a_0 and b_0, and that after an interval of time t from the start, the concentrations of C and D are both x, the velocity formula becomes

$$V=k_1(a_0-x)(b_0-x)-k_2x^2.$$

In the language of the differential calculus $V=\frac{dx}{dt}$, and the progress of this reversible reaction towards equilibrium is therefore represented by the equation

$$\frac{dx}{dt}=k_1(a_0-x)(b_0-x)-k_2x^2,$$

where k_1 and k_2 are so-called velocity coefficients, the numerical values of which are a quantitative expression of the rates of the forward and the back reaction respectively.

In cases where the position of equilibrium in the reversible reaction $A+B \rightleftarrows C+D$ lies practically at the right-hand extreme, the velocity of the back reaction becomes negligible, and the velocity equation may be written $\frac{dx}{dt}=k_1(a_0-x)(b_0-x)$, or simply, $\frac{dx}{dt}=k(a_0-x)(b_0-x)$. Integration of this equation leads to the formula $k=\frac{1}{(a_0-b_0)t}\cdot\log_e\frac{b_0(a_0-x)}{a_0(b_0-x)}$, and if in any particular case the progress of the change can be followed experimentally, *i.e.* if the values of x corresponding with various values of t can be ascertained, then k can be calculated, and the velocity of reaction at the temperature of experiment is quantitatively expressed thereby. In numerous cases the law of mass action, as embodied in the foregoing expression for k, has been verified experimentally; x, the amount of change in time t, varies with t in such a manner that $\frac{1}{(a_0-b_0)t}\cdot\log_e\frac{b_0(a_0-x)}{a_0(b_0-x)}$ remains constant.

As an illustration of the extent to which

these requirements of the law of mass action are fulfilled in an individual instance, the saponification of ethyl acetate by an equivalent amount of sodium hydroxide may be taken. This is a time reaction, the course of which may be followed by extracting samples of the reaction mixture from time to time and titrating for the residual alkali; the quantity of this naturally falls off as the change proceeds. In the following table the figures for a particular experiment are recorded, those in the first column representing the intervals from the start at which samples were extracted, those in the second column giving the relative alkalinity of each sample (alkalinity of initial mixture = 1·00), and those in the last column giving the calculated values of the velocity coefficient.

SAPONIFICATION OF ETHYL ACETATE BY SODIUM HYDROXIDE.

Minutes from start.	Relative alkalinity.	Velocity coefficient.
4	0·659	0·129
6	0·570	0·126
8	0·487	0·132
10	0·437	0·129
12	0·388	0·131
15	0·341	0·129
20	0·276	0·131

The satisfactory constancy of the figures in the last column demonstrates the applicability of the law of mass action in this case.

In the reaction $A + B \rightleftarrows C + D$, which has been taken as the basis of the argument, two molecules undergo change of concentration as the reaction proceeds, and the velocity coefficient k is accordingly described as the constant for a "bimolecular" reaction. On the same lines as those already followed, an expression can be obtained for the velocity coefficient of a "unimolecular" reaction, in which only one kind of molecule undergoes change of concentration; for this case it is found that $k = \frac{1}{t} \cdot \log_e \frac{a}{a-x}$, in which expression a is the initial concentration of the substance undergoing change, and x is its concentration after time t from the start. Where more than two molecules undergo change of concentration, *i.e.* for reactions of a higher "order" than the second, more complicated expressions are obtained for the velocity coefficient.

With these definite methods for expressing quantitatively the velocity of a chemical reaction at any given temperature, it becomes possible to state the influence of various factors on the velocity by recording the corresponding change in the velocity coefficients. In reference, for example, to the influence of temperature on the rate of a chemical change, it is customary to represent this effect by a statement of the increase in k for a temperature interval of 10°, *i.e.* by recording the value of the ratio $\frac{k_{T+10}}{k_T}$. The study of a very large number of cases has shown that for homogeneous changes, where the reaction system is entirely gaseous or entirely liquid, the value of $\frac{k_{T+10}}{k_T}$ lies, as a rule, between 2 and 3, the velocity being doubled or trebled for a rise of 10° C.

As with temperature, so with other factors which affect the rate of chemical change, the velocity coefficient provides a quantitative basis for their assessment. In relation to catalysis, in particular, it becomes possible to state the efficiency of one and the same catalyst at different concentrations, to determine whether the activity of the catalyst remains constant, and to compare the influence of different catalysts under given conditions.

Before proceeding to develop these considerations, it is desirable to state definitely what are the characteristics of a catalyst from the physico-chemical point of view. One of the main facts about a catalyst is that its quantity may be, and often is, exceedingly small in comparison with the quantities of the reacting substances which are affected. It has been stated, for example, that in the Schröder-Grillo process for the production of sulphuric acid, in which process the contact mass consists of finely divided platinum on magnesium sulphate, 5 grams of platinum are sufficient for an output of one ton of oleum per day, with a loss of only 20mg. platinum. It appears also, to take an example in another field, from information supplied to the writer by Mr. Maxted, that in the synthesis of ammonia with an iron-potash catalyst, an output of something like two tons of ammonia per litre of catalyst space can be obtained before it is necessary to change the catalyst.

Further, in normal circumstances the activity of the catalyst remains unimpaired when the reaction which it has accelerated is at an end. An interesting illustration of this characteristic of catalysts is furnished by Bredig's experiments on the influence of colloidal platinum in promoting the combination of hydrogen and oxygen at ordinary temperatures. In one case 2·5 cubic cm. of colloidal platinum

solution (containing 0·17 milligram of the metal) were shaken with electrolytic gas, and the decrease in the volume of the gas, due to the combination of hydrogen and oxygen, was determined at 10-minute intervals. The following results were obtained—

Time in minutes.	Decrease in the gas volume.	Decrease per minute.
10	17·8 ccs.	1·78
20	35·8 ,,	1·80
30	54·8 ,,	1·90
40	72·4 ,,	1·76
50	90·2 ,,	1·78

The figures in the last column of the table afford no evidence of any decrease in the activity of the colloidal platinum as the reaction proceeds. Further, the same colloidal platinum was shaken intermittently for fourteen days with the hydrogen + oxygen mixture, about 10 litres of which were converted to water in this interval. Not only is the contrast between the minute quantity of the catalyst and the extent of the induced change sufficiently striking, but it was found at the end of the fourteen days that the rate of decrease of the gas volume, measured over successive 10-minute intervals with constant shaking, as at the beginning of the experiment, was 2·02, 1·87, 1·95, 1·97, and 2·01 cubic cm. per minute. Plainly, the catalytic efficiency of the platinum is no lower at the end of the experiment than at the commencement.

Now, in the technical applications of catalysis one of the most serious problems has been precisely how to keep the catalyst in a state of unimpaired efficiency. However active the contact substance may be at the start, it is useless from the technical standpoint unless it has a reasonably long life. This difficulty does not arise with a dissolved catalyst, such as an acid in the hydrolysis of starch; but where the catalyst is a solid substance, when we are dealing with a case of so-called "heterogeneous" catalysis, then the problem is a serious one. In many instances the technical development of a promising catalytic reaction has been held up by the difficulty of preserving the catalyst in its full activity. The catalyst deteriorates owing to the presence of some foreign substance, or "poison," in the materials which are reacting under the influence of the catalyst.

A notable example of this difficulty is furnished by the history of the development of the sulphuric acid contact process. So long as absolutely pure gases are employed, it appears that the platinum catalyst maintains its efficiency. In one case which has been put on record, where sulphur dioxide, obtained by the evaporation of the liquid substance, was mixed with filtered air and passed over the contact mass, a 95 per cent. yield of sulphur trioxide was still given by platinised asbestos which had been in the plant for about ten years continuously without renewal. It is a fair inference that the catalytic action of platinum continues indefinitely if pure gases are employed.

The record, however, of the prolonged efforts of the Badische Anilin- und Soda-Fabrik to utilise for the purpose of the sulphuric acid contact process the gases obtained by roasting blende or pyrites demonstrates the extreme sensitiveness of the platinum catalyst to impurities. It was found that even when the pyrites gases were cooled by passage through long metal pipes, repeatedly scrubbed with sulphuric acid, and finally filtered through dry coke and asbestos, the contact mass gradually became less effective and finally lost its power altogether. The discovery was made that certain substances, notably arsenic, are specially injurious to the catalytic efficiency of platinum, and further investigation showed that even the drastic purification just described had failed to remove the last traces of arsenic from the pyrites gases.

The sulphuric acid "mist" or "fume" in these gases is extraordinarily persistent, and apparently is the carrier of the arsenic. The removal from a stream of gas of those impurities which are in a very finely divided liquid or solid condition is recognised as sometimes a more difficult operation than the absorption of gaseous impurities by chemical means. In the case of the sulphuric acid contact process it was only after much patient labour that means were found, including slow cooling, thorough scrubbing and wet filtration, for removing all traces of "poisons" from the pyrites gases. During the last few years a novel method of dealing with all sorts of mist and fume has been introduced by Cottrell, based on the fact that a strong electrical field promotes the settlement and precipitation of suspended particles. Numerous plants involving this principle have been designed and erected, more particularly in connection with smelting works and blast furnaces, and the same process is being applied for the removal of the mist from the pyrites gases employed in the sulphuric acid manufacture.

The serious difficulties encountered in using pyrites gases in the sulphuric acid contact

process gave some support to the belief that the poisoning of the catalyst was inevitable, and it was accordingly suggested that the platinum should be deposited on a soluble carrier, so that when the contact substance lost its efficiency the valuable metal could be recovered quite easily by appropriate treatment. This was the method employed in the Schröder-Grillo process, a very active catalyst being prepared by soaking magnesium sulphate in the solution of a platinum salt, and then heating in the presence of sulphur dioxide: when the contact mass has been formed the platinum is about 0·1 per cent. of the whole.

The fact that the amount of a catalyst may be almost infinitely small compared with the quantities of the substances which react under its influence makes it extremely probable that the final state of the reactive system must be independent of the catalyst. This would mean, for a reversible reaction in particular, that the state of equilibrium finally attained will be the same whether the catalyst is there or not. The true catalyst, that is, will influence only the rate at which equilibrium is established, not the position of equilibrium itself, or the energy change accompanying the reaction. The catalyst may be compared to the oil which facilitates the sliding of a weight down an inclined plane, without affecting the total energy derivable from the fall of the weight.

Illustrative confirmation of this important conclusion is furnished by Turbaba's work on the equilibrium between acetaldehyde and paraldehyde. The equilibrium mixture of these two substances at 50·5° contains 33·9 per cent. of acetaldehyde and 66·1 per cent. of paraldehyde, and the conversion of paraldehyde into this mixture is accompanied by a marked and easily measurable increase of volume. The change is accelerated by a variety of substances, but it was found that with different catalysts in varying quantity the difference in volume of the paraldehyde and the equilibrium mixture is practically the same in every case, as is shown by the following figures:—

Paraldehyde $\rightleftarrows$ Acetaldehyde.

Catalyst.	Per cent. Catalyst.	Percentage Increase of Volume.
Sulphur dioxide	0·08	8·20
" "	0·002	8·19
Zinc sulphate	2·7	8·13
Hydrochloric acid	0·13	8·13
Oxalic acid	0·52	8·27
Phosphoric acid	0·54	8·10

Clearly, the percentage increase of volume is independent of the particular catalyst employed, and, in the case of sulphur dioxide, independent also of the amount of catalyst. In this case, then, and in fact for all truly catalytic reversible reactions, the catalyst affects only the velocity of the change, not the composition of the equilibrium mixture. If this statement were not correct, then the investigation of equilibrium reactions in presence of catalysts and the evaluation of equilibrium constants, as in the sulphuric acid contact process and the ammonia synthesis, would be an unjustifiable proceeding.

If now, in any reversible reaction the position of equilibrium is unaffected by the catalyst, it follows that the value of the equilibrium constant K is unaltered. This constant, however, as was shown in the previous lecture, is the ratio of two velocity coefficients, k_1 and k_2, which refer to the forward and the back reactions respectively. It follows therefore that k_1 and k_2 must be affected in equal degree by the catalyst; that is, the catalyst accelerates the forward and the back reactions in the same proportion. The mere fact that iron and nickel promote the decomposition of ammonia at high temperatures suggested that these metals would act as catalysts for the opposed reaction also, viz., the union of nitrogen and hydrogen. This was found to be the case. Again, in the absence of a catalyst, sulphur trioxide once formed appears to be remarkably stable at high temperatures, even where the equilibrium constant for the reaction $2SO_3 \rightleftarrows 2SO_2 + O_2$ would require a far-reaching decomposition into sulphur dioxide and oxygen. The rate of decomposition, no less than the rate of synthesis, is determined largely by the presence of an appropriate catalyst.

With these characteristics of catalysts in mind we may endeavour to apply the conceptions of reaction velocity and the formulæ embodying these conceptions for the purpose of a rational study of catalysis. The success which has attended the physical chemist's efforts along these lines has been much more notable in some directions than in others, and it has become clear that a distinction must be drawn between "homogeneous" catalysis on the one hand and "heterogeneous" catalysis on the other. In the former case the catalyst is in the same physical state (gaseous or liquid) as the substances which are reacting; in the latter, the catalyst is solid, and cannot be in a condition of true homogeneous mixture with the reacting compounds.

The systematic study of homogeneous catalysis has led to very definite and interesting results, some of which may be illustrated by a couple of examples. The first of these refers to the influence of the *concentration* of the catalyst, and is based on a study of the rate at which diazoaminobenzene is converted into aminoazobenzene. This change takes place in aniline solution when an aniline salt, acting as catalyst, is present. The course of the reaction can be followed quantitatively, and the rate of change is expressible by a velocity coefficient, the value of which varies in direct proportion to the concentration of the catalyst, other conditions being unaltered. This is apparent from the following figures:—

Diazoaminobenzene $\rightleftarrows$ aminoazobenzene.

Concentration of aniline hydrochloride.	Velocity coefficient at 25°.
0·1	0·0060
0·2	0·0123
0·3	0·0180

Again, in cases of homogeneous catalysis, it is possible to compare the efficiency of different catalysts under given conditions. The change of cane sugar, for example, into invert sugar takes place with appreciable rapidity in presence of an acid as catalytic agent, and can easily be followed with a polarimeter. The course of the reaction is in harmony with the formula for a unimolecular reaction, *i.e.* the velocity coefficient $k = \frac{1}{t} \log_e \frac{a}{a-x}$. This will be seen from the following table:—

Inversion of cane sugar by $\frac{N}{2}$ HCl at 25°.

t minutes.	Angle of rotation.	$\frac{1}{t} \log_e \frac{a}{a-x}$.
0	+25·16°	—
56	16·95°	·00501
116	10·38°	·00501
176	5·46°	·00504
236	1·85°	·00504
371	−3·28°	·00508
∞	−8·38°	—

Now it is found that the rate of inversion of cane sugar at a given temperature in presence of acid of a definite normality varies notably with the nature of the acid. Thus the catalytic efficiency of hydrochloric acid in promoting the inversion of sugar is greater than that of sulphuric acid and acetic acid at the same temperature and the same concentration, and indeed, for $\frac{N}{2}$ concentration, the velocity coefficients obtained in the three cases stand in the ratio 100 : 54 : 0·4. So far, then, as homogeneous catalysis is concerned, the evaluation of velocity coefficients provides a rational method of comparing the activity of different catalysts under the same conditions.

The majority of the technically important catalytic reactions belong, however, to the "heterogeneous" class, and in these cases the application of the reaction velocity formulæ already discussed and illustrated cannot be carried through to anything like the same extent. Indeed, the careful study of cases of heterogeneous catalysis on quantitative lines reveals the fact that other factors are operative besides mass action. This is brought out very clearly, for example, by Bone and Wheeler's research on the combination of hydrogen and oxygen at hot surfaces.

In this work provision was made for the circulation of hydrogen and oxygen through a tube packed with fragments of unglazed porcelain and maintained at a constant temperature, the gradual combination of the gases which took place under these conditions being followed quantitatively by determinations of the pressure from time to time. Plainly, as the reaction $2H_2 + O_2 = 2H_2O$ proceeds, the pressure falls regularly and provides a record of the progress of the change. From such a record the velocity of combination of the gases may be calculated.

On the ground that two distinct substances disappear during this reaction it might fairly be expected that the course of the change would conform to the bimolecular or the trimolecular type. The surprising result, however, has emerged that the rate of reaction is represented by the unimolecular formula. In support of this the following figures, obtained with normal electrolytic gas at 450°, may be quoted: k_1 is the velocity coefficient calculated by the unimolecular formula, k_2 is that based on the bimolecular formula.

t hours.	Pressure in mm.	k_1.	$k_2 \times 10^6$.
0	465·6	—	—
12	324·0	·0131	78·2
24	228·6	·0129	92·8
36	163·9	·0126	109·8
48	116·1	·0125	134·7
72	60·7	·0123	199·0
96	28·6	·0126	341·8
120	14·6	·0125	552·7

Experiments were made also in which the initial mixture contained hydrogen and oxygen in other than the volume ratio 2 : 1, and in which the partial pressures of the separate gases

were ascertained at each stage, as well as the total pressure. A unimolecular constant was then calculated for the rate of disappearance of each gas separately, viz. k_{H_2} and k_{O_2}, and it was found that the former alone was constant. This important result may be illustrated by the figures obtained with a mixture of 3 volumes of hydrogen with 1 volume of oxygen, circulated over porcelain at 430°. The quantities P_{H_2} and P_{O_2} are the partial pressures of hydrogen and oxygen at the successive stages.

t hours.	P_{H_2} mm.	P_{O_2} mm.	k_{H_2}.	k_{O_2}.
0	292·5	94·9	—	—
2	260·5	78·9	·0253	·0401
4	230·5	63·9	·0259	·0429
6	206·2	51·8	·0253	·0438
8	185·9	41·7	·0246	·0447
12	151·8	24·6	·0237	·0488
16	123·6	10·4	·0240	·0600

From these and other figures it appears that the rate of change is proportional to the partial pressure of the hydrogen, and this must mean, as Bone has pointed out, that the formation of steam is an indirect process, dependent on a primary change, at the surface of the catalyst, in which hydrogen is concerned. The evidence favours the view that the catalytic action of porcelain depends on the occlusion of the reacting gases on its surface, and the results quoted above indicate that the rate of change is determined mainly by the rate of occlusion of the hydrogen. Hence in studying the catalysis of hydrogen and oxygen at hot surfaces it is not really the velocity of a chemical reaction that is being measured, but the rate of a purely physical process. The operation of the law of mass action is masked, and it may be that the chemical combination of the hydrogen and the oxygen at the surface of the catalyst is exceedingly rapid, perhaps instantaneous.

The investigations to which reference has just been made laid the foundations for the introduction of what is known as "surface combustion," in which the catalytic effect of hot surfaces in promoting combustion receives practical application. A homogeneous explosive mixture of inflammable gas and air is made to burn without flame in contact with a granular solid, the latter acting as an accelerator of the combustion, and becoming itself incandescent. In various ways, a description of which would lie outside the scope of these lectures, this surface combustion may be employed for such purposes as the concentration and evaporation of liquids, for heating muffle furnaces, and for steam raising.

In another field, lying far apart from that of combustion, heterogeneous catalysis is found to present various features which are foreign to the law of mass action. Some of the most important catalytic reactions, including many of technical significance, are those which take place under the influence of enzymes. These are catalysts, formed by living organisms and of very complex nature, which promote in a remarkable degree many changes in organic matter. To this class of catalysts belong, for example, invertase, diastase, and the enzymes of yeast.

In certain cases the hydrolysis of carbohydrates under the influence of enzymes is marked by the peculiarity that during the first stages the amount of change is a linear function of the time, *i.e.* a constant weight of the carbohydrate is hydrolysed in a given interval of time. Such behaviour is not in harmony with the logarithmic mass action formula, $k = \frac{1}{t} \log \frac{a}{a-x}$, which, as already shown, does represent accurately the course of hydrolysis of cane sugar under the catalytic influence of acids.

A case in point is the action of diastase on starch, the earlier portion of the time curve being linear, the later portion being logarithmic in character. This is proved by calculating the velocity coefficient $k = \frac{1}{t} \log \frac{a}{a-x}$, (1) for each observation from the start of the reaction, (2) for each observation after the linear portion of the time curve has been passed, a new starting-point being chosen. A comparison of two sets of values of k obtained in this manner is given in the following table, which refers to the hydrolysis of a 3 per cent. starch solution by malt extract at 51–52°:—

Time (min.)	k	Time in min. from new starting-point.	k
10	·00498	—	—
20	·00553	—	—
30	·00590	—	—
40	·00620	0	—
50	·00650	10	·00842
60	·00690	20	·00831
70	·00706	30	·00821
80	·00728	40	·00837
90	·00730	50	·00818
100	·00732	60	·00807
110	·00749	70	·00822
120	·00762	80	·00840
130	·00779	90	·00855

It appears from the figures quoted that if the first portion of the change is left out of account, practically constant values for the velocity coefficient are obtained, and it is a fair conclusion that the later portion of the change conforms to the law of mass action. The linear relationship between the time and the amount of change is observed only when the amount of enzyme is relatively small compared with the amount of carbohydrate. Certain recent work indicates that with purified malt diastase the abnormal period of the linear relationship is very short indeed.

The combination of hydrogen and oxygen at the surface of hot porcelain, and the action of diastase on starch, have been discussed in detail previous history of the catalyst may exert on its activity, some observations made by Bone and Wheeler on porcelain surfaces may be quoted. These investigators found that previous treatment of such a surface with hydrogen stimulated quite notably its activity in connection with the combustion of hydrogen and oxygen. Preliminary treatment of the porcelain surface with oxygen appears, on the other hand, to reduce its catalytic activity. These statements are borne out by the following figures: k, the velocity coefficient, represents, as already explained, the rate at which the hydrogen and oxygen combine to form water. The porcelain surface was the same throughout, and the experiments were performed in the order shown.

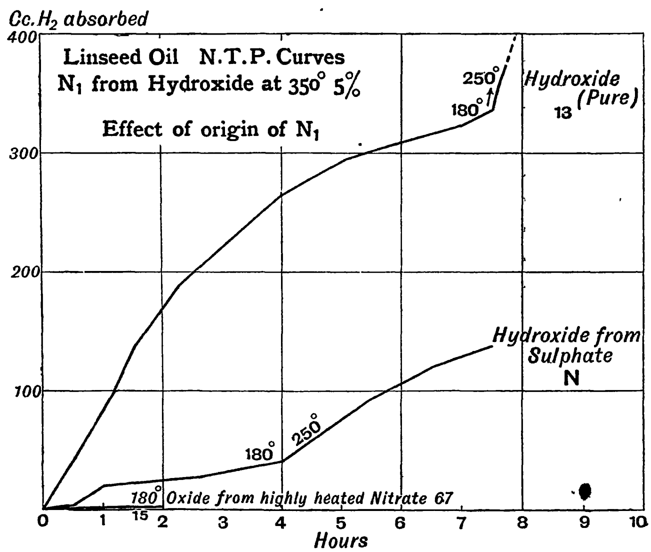


Fig. 1.

in order to illustrate some of the complications that arise in applying the mass action formulæ in cases of heterogeneous catalysis. Another very serious obstacle in this matter is the extreme difficulty, one might almost say the impossibility, of reproducing the catalyst in any desired condition of activity. In heterogeneous catalysis the scene of action lies in the surface layers of the solid catalyst, and it is well known in connection with technical catalysed reactions that the activity of the surface depends, in a very high degree, on the way in which the catalyst has been prepared and on the treatment it has received.

As an illustration of the influence which the

Previous exposure to—	k
Hydrogen for 24 hours . .	·0515
Oxygen ,, 24 ,, ...	·0305
Hydrogen ,, 40 ,, ...	·0592
Oxygen ,, 48 ,, ...	·0373
Hydrogen ,, 72 ,, ...	·0622

Normal value for k = ·0430.

It is noteworthy that the stimulus imparted to the porcelain surface by preliminary hydrogen treatment survived a prolonged exhaustion of the apparatus, but gradually wore off as successive charges of electrolytic gas were circulated over the surface.

The significance of the previous history factor may be emphasised also in relation to one of the most important applications of catalysis on

the technical scale, viz., the hydrogenation of oils. The development of this modern industry is based on the classic investigations of Sabatier and Senderens relating to the reduction of organic compounds by hydrogen in presence of reduced nickel. Among other points which these workers established, it was shown that the vapour of oleic acid, an unsaturated compound, when treated with hydrogen in presence of nickel at 280–300°, was almost completely converted into the corresponding saturated compound, stearic acid.

This observation, however interesting in itself from the purely scientific standpoint, would scarcely have led to extensive technical developments, but work by others on the same lines showed that if hot oleic acid, in the *liquid* condition, is treated with a current of hydrogen in presence of a metal catalyst, such as finely divided nickel, the hydrogen is absorbed and complete conversion into stearic acid is effected. Further, this method is applicable not only to the liquid unsaturated fatty acids, but also to their glycerides, *i.e.* the liquid fats such as olive, linseed, and fish oils. As a result of this discovery the hardening of animal and vegetable oils has developed into a big industry, the hardened fats obtained by hydrogenation being employed in the manufacture of soap, or, in some cases, for edible purposes.

The very existence of this big industry is bound up with the successful preparation of catalyst metals, more especially nickel and experience has shown that the activity of this metal is a function of its previous history. The nickel is in almost all cases obtained by reduction, but it turns out that the catalytic efficiency depends on whether it is the oxide or the hydroxide which is reduced; it varies with the salt from which the oxide or hydroxide is obtained, and with the temperature at which the reduction is effected. The influence of some of these factors is made clear by the diagram (Hehner) shown on page 114, from which it appears that nickel prepared from the oxide, obtained in its turn by strongly heating the nitrate, is almost without catalytic activity in the hydrogenation of linseed oil. If the metal is prepared by reducing the hydroxide, obtained from nickel sulphate, there is a distinct improvement, but if hydroxide from nickel nitrate is reduced a catalyst of great activity results. Again, if nickel carbonate is ignited at 400–450°, and the resulting oxide is then reduced with hydrogen at 400°, a product of comparatively poor catalytic qualities is obtained; if, however, the ignition and reduction are both carried out at 300°, the resulting nickel is highly active.

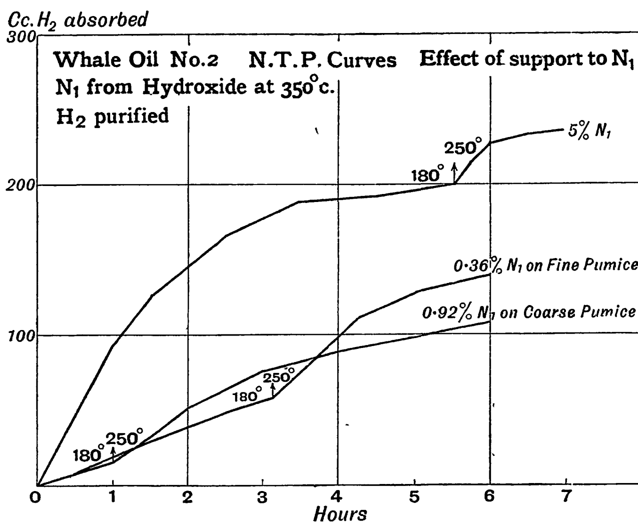


FIG. 2.

All this may be regarded as very capricious behaviour on the part of the nickel, but certainly furnishes strong evidence as to the difficulty of reproducing a catalyst of a given degree of activity. That, as already stated, is one of the difficulties in the study of heterogeneous catalysis on quantitative lines.

The degree of subdivision of the nickel catalyst

is naturally also an important factor. The hydrogenation presumably takes place at the nickel-oil surface, and the increase of surface which is involved in the progressive mechanical subdivision of a given weight of material may therefore be expected to lead to increased catalytic activity. One common method of securing greater surface extension of the nickel catalyst in the hydrogenation process is to use a porous carrier, such as kieselguhr or pumice. These materials may be impregnated with nickel salt, followed by precipitation of the hydroxide and reduction at a suitable temperature. The effect of such an increase of the contact surface is illustrated by the two lower curves in Fig. 2 (Hehner), given on page 115.

Other efforts to prepare a very finely divided and therefore presumably highly active nickel catalyst have centred round nickel carbonyl. This compound, when mixed with the oil and heated to about 200°, decomposes completely and gives a fine suspension of the metal which is a very effective catalyst. There is, however, another manner in which nickel carbonyl may be used as the source of an active nickel. This process (Lessing) consists in *continuously* supplying nickel carbonyl along with the stream of hydrogen which is charged into the hydrogenation chamber. At the temperature which prevails there the carbonyl is decomposed, and the nickel at the moment of liberation presents a maximum surface development, and accordingly a very high catalytic power. It is said that excellent results are obtained even when the proportion of nickel to oil is as low as 1:1000.

Like other catalysts, the nickel employed in the hydrogenation of oils is very sensitive to certain poisons, among which chlorine and sulphur are prominent. The most important question, however, which has emerged in this connection is whether carbon monoxide is to be reckoned as a "poison" for nickel, and whether, therefore, there is any objection to the use in the hydrogenation process of a hydrogen obtained from water gas. Opinion appears to have differed on this point, but it now seems to be established that carbon monoxide exerts a marked poisoning effect on the hydrogenation of oils in presence of nickel. This conclusion may be based, for example, on Maxted's experiments in which separate charges of olive oil, each containing 1 per cent. of a stock nickel catalyst, were agitated with pure hydrogen or a hydrogen contaminated with a small known proportion of carbon monoxide. The volumes of hydrogen (in cubic cm.) absorbed by 10 grams of oil at 180° in the various cases are recorded in the following table:—

		Carbon Monoxide.			
Time in Minutes.	Pure Hydrogen.	0·25 per cent.	0·5 per cent.	1·0 per cent.	2·0 per cent.
5	86	72	67	58	28
10	143	122	111	93	57
15	194	159	142	116	76
20	248	193	168	136	91
30	348	252	213	164	114
50	515	352	281	215	146

An examination of these results shows that the first traces of carbon monoxide have relatively the greatest retarding effect on the velocity of hydrogenation.

The features of heterogeneous catalysis may be further emphasised in connection with a technical process which is of great and growing importance at the present moment, viz., the oxidation of ammonia. This operation, although it has been known on the commercial scale since about 1902, assumed peculiar significance during the war, for obvious reasons, and it is stated that in Germany as much as 100,000 tons of nitric acid have been produced in this way annually by one process alone.

The importance of securing other supplies of nitrates than Chili saltpetre has been recognised in this country, and steps have been taken to put the oxidation of ammonia on a sound technical basis. The United States Government, on its part, has allocated a sum of no less than £20,000,000 to the erection of factories for the production of nitric acid by the oxidation of ammonia.

The conversion of ammonia into nitric acid is effected as a rule with a platinum catalyst in the form of gauze or net, through which the mixture of ammonia and air is forced. Quite a good yield is obtained without continuously heating the gauze, but provision may be made for passing an electric current across the gauze, sufficient to maintain it at a dull red heat, say, 600–700°. The reaction is represented by the equation $4NH_3 + 5O_2 = 4NO + 6H_2O$, and is accompanied by a considerable evolution of heat.

One of the most remarkable features about this catalytic combustion of ammonia is the very high yield obtained even when the passage of the gases is extremely rapid. Thus with a

mixture of 1 volume of ammonia and 7·5 volumes of air flowing over a 6 in. × 4 in. gauze at the rate of 20 cubic feet per minute, over 90 per cent. conversion can be obtained. That such a brief period of contact of the reacting gases with the catalyst, of the order of 0·01—0·001 second, should be sufficient for the occurrence of the change is indeed very striking.

It has been stated in connection with a description of the converters designed in this country during the war that an output of 1·5 tons of pure nitric acid per square foot of catalyst area per twenty-four hours, with an efficiency of 95 per cent., has been regularly achieved. Hence, it has been calculated, the output of nitric acid per gram of platinum is no less than 15 kilograms in the twenty-four hours. This is a remarkable illustration of the first characteristic of a catalyst to which reference has already been made in this lecture, viz., that the amount of the catalyst may be extremely small compared with the quantities of the reacting substances transformed under its influence.

In relation to efficiency, the character and condition of the surface of the platinum catalyst is all-important. Platinum black and sponge are both too active, and promote an oxidation of the ammonia in another direction, viz., to nitrogen and steam. Massive platinum, on the other hand, with a bright surface, is almost without catalytic activity, and something between this and black or sponge furnishes the most effective surface for the oxidation to nitric oxide.

New gauzes are not very effective catalytically, but are "activated" by passing an ammonia-air mixture at a bright-red heat. The bright surface of the platinum becomes dulled in this process, and the catalytic activity increases.

It is, in view of what is generally known, not surprising that the platinum catalyst is very sensitive to certain foreign substances. The ammonia gas must be freed from such possible contaminations as phosphine, silicon hydride, hydrogen sulphide and acetylene, each of which would "poison" the contact substance. It is found necessary also to filter the gases very thoroughly, since dust, especially if it carries with it particles of iron oxide, has a notably deleterious effect on the platinum. For this reason it is found advisable to avoid contact of the filtered gases with iron pipes, from which traces of oxide might be detached and carried along with the gas current; the converter and the piping which leads to it are therefore suitably constructed of aluminium. Provided that "poisons" are excluded by the precautions just indicated, the "life" of the catalyst is fairly prolonged; it is said that even when the oxidation process is carried on uninterruptedly the platinum gauze remains effective for several months.

The brief review which has been given of some prominent cases of industrial catalysis would lead up naturally to a discussion of the *modus operandi* of the catalyst, but this is somewhat outside the scope of the present lectures. Suffice it to say that, according to one view, the acceleration of a chemical change due to the catalyst is brought about by the rapidly alternating formation and decomposition of an intermediate compound or compounds of which the catalyst forms a part. Thus, for example, the effect of spongy platinum in promoting the combination of a mixture of hydrogen and oxygen is attributed to the primary formation of an oxide of platinum, which in its turn is reduced by the hydrogen, yielding water and the original metal. Similarly, the reduction of unsaturated organic compounds by hydrogen in the presence of a nickel catalyst is supposed by some to be effected by the preliminary formation of nickel hydride.

Such a chemical view of the mechanism of catalysis can be defended only if the rate of formation and decomposition of the intermediate compound is greater than that of the uncatalysed reaction. In many cases, too, the participation of the catalyst in some intermediate reaction is, to say the least, highly improbable, and in such instances it seems that the catalyst performs some purely physical function. Reference has been made to the catalytic combination of hydrogen and oxygen at hot surfaces, and in this connection it is exceedingly difficult to believe that porcelain acts as a catalyst by undergoing alternate reduction and oxidation. Rather does the surface of the solid in such heterogeneous catalyses appear to provide for some condensation or concentration of the reacting gaseous or liquid substances, the actual chemical change taking place then with high rapidity. Although this view does not presuppose any chemical intervention of the catalyst, it does not exclude the possibility that the *physical* condition of the surface may be altered by the reaction. Indeed, there is evidence in various cases that this actually occurs. When, for example, ammonia is passed

over metals at high temperatures and so decomposed, the physical properties of the metals undergo notable alteration, even although no nitrogen has been permanently fixed. Again, the reader may be reminded of the oxidation of ammonia at a hot platinum gauze, in which connection it has already been pointed out that during "activation" the appearance of the platinum surface undergoes a distinct change, passing from a bright condition to a dull one.

Altogether, there is no single theory which can interpret every case of catalysis, and it is certain that in seeking an explanation for the mode of action of the catalyst, both physical and chemical factors must be taken into account.

CORRESPONDENCE.

CAPYBARA SKINS.

In the *Journal* of October 18th, 1918, a note on the Capybara of South America mentioned that no use had as yet been found for the hide of this animal. It occurred to me that I had heard of some use to which it was put, and I subsequently had an opportunity of learning from a friend who has spent some years in Buenos Ayres that the skin referred to is used as a *poestra*, or saddle blanket, in that region. It is tanned, I understand, and in this state is soft and fairly durable. This may be of interest to your readers.

JAMES AIKEN.

Manse of S. James Parish, Forfar,
Dec. 31st, 1918.

OBITUARY.

COLONEL THEODORE ROOSEVELT.—Colonel Theodore Roosevelt, ex-President of the United States of America, died in his sleep at his residence at Oyster Bay on the 6th inst. Born in 1858, he was educated at Harvard, and elected a member of the New York Legislature in 1882. He rapidly made his mark in politics, and became leader of the minority in 1883, leader of the House in 1884, U.S. Civil Service Commissioner in 1889, President of the New York Police Board in 1895, and Assistant Secretary of the Navy in 1897. In 1898 he organised the 1st U.S. Cavalry Volunteers (Roosevelt's Rough Riders), and commanded them in Cuba. He was Governor of New York State from 1898 to 1900, and Vice-President of the United States in 1901. On the murder of President McKinley in that year he became President, a post which he continued to hold till 1908.

Full details of his public life and policy, as well as of his career as a hunter of big game in Africa, Brazil and elsewhere, have appeared during the present week in the daily press, and it is scarcely necessary to dwell upon them here. It may be permissible, however, to refer to the tremendous ardour with which he backed the cause of the Allies in America. Probably no one was more impatient than he to see the United States declare themselves in unqualified terms the enemies of the Central Powers. All his four sons fought in the war. Captain Kermit Roosevelt served with distinction in the British Royal Artillery in Mesopotamia before he was transferred to the American Artillery last July; Lieutenant Quentin Roosevelt was killed in an air fight over the Marne battlefield; while the other two brothers, Theodore and Archibald, were also wounded. In speaking of them, the ex-President said that his only regret was that he could not fight at their side.

In 1910 Colonel Roosevelt was elected a life member of the Society under the terms of By-Law 61, which empowers the Council to admit annually five persons eminent in arts, manufactures or commerce to the privilege of life membership without the payment of any subscription.

BRIGADIER-GENERAL ALEXANDER BEAMISH HAMILTON, C.B.—Brigadier-General A. B. Hamilton, who died at Weymouth on December 30th at the age of fifty-eight, was elected a member of the Royal Society of Arts in 1900. He entered the Army in 1881, was Adjutant of the King's Own Scottish Borderers from 1890 to 1903, and promoted colonel in 1911. He was D.A.A.G. in Egypt from 1893 to 1898; he served in the Chin-Lushai expedition and the Nile expedition in 1898, and was D.A.Q.M.G. in South Africa from 1905 to 1908. From 1911 to 1913 he was Embarkation Staff Officer, Southern Command, and Embarkation Commandant since 1914. He was mentioned in despatches and received the C.B. in 1915.

GEORGE FREDERICK MORT.—Mr. G. F. Mort, who joined the Royal Society of Arts last year, died at his residence on Ealing Common on December 21st at the age of forty-five. He was educated at Bilton Grange, Aldenham; New College, Oxford; Glasgow University; and University College, London.

In 1902 he started business as an engineer, under the title of New Engine, or N.E.C. Car. Later on he took up the designing of aeroplane engines. His most successful engine was of 50 h.p., and this type was the only English machine entered for the Gordon-Bennett race at Eastchurch in 1911. When the war broke out Mr. Mort gave himself up to the manufacture of parts of foreign engines adopted by this country, and his devotion to this work was no doubt responsible for his early death.

NOTES ON BOOKS.

THE MANUFACTURE OF ALUMINIUM. By J. T. Pattison, F.C.S. London: E. & F. N. Spon, Ltd. 7*s*. 6*d*. net.

Most of the information on the subject of the manufacture of aluminium is scattered in various papers and articles, and it has consequently been

difficult to find when wanted; but this has now been put together in a succinct and handy form. Mr. Pattison had charge for some time of the chemical laboratory of the Aluminium Corporation, Limited, at Wallsend-on-Tyne, and he had thus exceptional opportunities of studying the processes of manufacture in use there.

After a brief historical survey of these processes, which originated with Humphry Davy's successful attempt in 1807 to decompose the alkali metals by means of the electric current, the author describes the occurrence of aluminium, the manufacture of carbon electrodes and of pure alumina, the founding of aluminium, its alloys, and its various uses and applications. A great deal of information is condensed into a small space, and an excellent account is given of a metal which from its lightness and durability seems destined to be applied to almost innumerable uses.

Spons' Practical Builders' Pocket-book. Edited by Clyde Young, F.R.I.B.A. London: E. & F. N. Spon, Ltd. 10*s.* 6*d.* net.

Most architects and builders are familiar with this handy book of reference, and its popularity is shown by the fact that a fresh edition has been called for. Some sixty more pages have been added, and the volume now contains an immense amount of information conveniently arranged. The only question which the last edition raises is whether the book is not in danger of becoming too heavy to be carried with comfort in one's pocket. It would be difficult to say, however, that any parts might be omitted with advantage; but those who habitually carry the book about with them (as many do) will hope that the 510 pages of which it now consists will not be materially added to in future editions.

GENERAL NOTE.

Future Sources of Potash in America.—It is said that England is now recovering from blast-furnace gas nearly as much potash as was imported from Germany before the war. Rapid progress is being made in America in this direction. How long the cement industry will continue to be the chief producer of by-product potash in the United States is a matter of conjecture. Already blast-furnaces are looming up as a strong competitor, and before long may become one of their important sources of potash reclamation. A 200-ton blast-furnace smelts as much potash-bearing materials in twenty-four hours as a 3,000-barrel cement plant in the same length of time. The recovery of potash opens another avenue for cost reduction, not in mills but in cents per ton of iron. It remains to be seen, says the *Iron Trade Review*, whether or not American blast-furnace men will take advantage of the opportunity to break another of Germany's economic weapons which she intends to wield after the war.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

January 15.—A. F. Kendrick, Department of Textiles, Victoria and Albert Museum, "English Carpets." Sir William M. T. Lawrence, Bt., will preside.

January 22.—Colonel H. G. Lyons, D.Sc., F.R.S., Acting Director of the Meteorological Office, "Meteorology during and after the War." Sir William Napier Shaw, D.Sc., F.R.S., Meteorological Adviser to the Government, will preside.

January 29.—Frederick William Keeble, C.B.E., M.A., Sc.D., F.R.S., Director of Horticulture, Food Production Department, "Food Production by Intensive Cultivation." Lord Lambourne, C.V.O., will preside.

February 5.—Edward Carstensen de Segundo, A.M.I.C.E., M.I.Mech. E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes." Lord Lamington, G.C.M.G., G.C.I.E., will preside.

February 12.—Sir Frank Heath, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

February 19.—John Francis Crowley, D.Sc., A.M.I.E.E., "The Use of Electricity in Agriculture in Germany." Sir John F. C. Snell, M.Inst.C.E., will preside.

February 26.—W. L. Hichens (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry."

March 5.—B. D. Porritt, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

March 12.—

March 19.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

Indian Section.

Thursday afternoons, at 4.30 p.m.:—

January 16.—H. Kelway-Bamber, M.V.O. (late Superintendent of Rolling Stock, East Indian Railway), "Coal and Mineral Traffic on the Indian Railways." Sir Charles H. Armstrong, Chairman, Great Indian Peninsula Railway Company, will preside.

February 13.—

March 13.—

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

FEBRUARY 4.—

MARCH 4.—PROFESSOR JOHN CUNNINGHAM McLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

MAY 27.—SIR EDWARD R. DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced:—

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JANUARY 13...Chadwick Lecture, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m. Mr. A. H. Barker, "Fuel Economy and Health." (Lecture II)

Geographical Society, Burlington-gardens, W., 8 p.m. Mr. J. Berry, "Transylvania and its relation to Ancient Dacia and Modern Rumania."

TUESDAY, JANUARY, 14...Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Mr. R. J. Cracknell, "Sheep Freezing in Patagonia."

Royal Institution, Albemarle-street, W., 3 p.m. Professor S. Wilkinson, "Lessons of the War." (Lecture I.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Mr. A. G. Cooper, "Slips and Subsidences on the Ceylon Government Railways." 2. Mr. F. W. Scott, "Pietermaritzburg-Riet Spruit Deviation."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 6.30 p.m. Mr. G. Giles, "Estimates Free," and "Measuring and Valuing of Decorative Work."

Colonial Institute, Central Hall, Westminster, S.W., 8 p.m. Dr. V. Cornish, "Geographical Securities for the British Empire."

Industrial Reconstruction Council, 2, Tudor-street, E.C., 6 p.m. Major H. J. Gillespie, "Reconstruction or Restoration."

WEDNESDAY, JANUARY 15...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. A. F. Kendrick, "English Carpets."

Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.45 p.m. Dr. L. E. Stamm, "Medical Aspects of Aviation."

Meteorological Society, at the Geological Society, Burlington House, W., 5 p.m. 1. Annual General Meeting. 2. Address on "Meteorology: the Society and its Fellows," by Sir Napier Shaw, President.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor W. A. Bone, "Coal and National Health."

Microscopical Society, 20, Hanover-square, W., 8 p.m. Mr. J. E. Barnard, Presidential Address on "The Limitations of Microscopy."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Professor W. L. Courtney, "The Perfect Artist—and Sophocles."

THURSDAY, JANUARY 16...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. H. Kelway-Bamber, "Coal and Mineral Traffic on the Indian Railways."

Linnean Society, Burlington House, W., 5 p.m. 1. Captain A. W. Hill, "The Care of Soldiers' Graves" (with lantern-slides). 2. Mr. N. E. Brown, "Old and New Species of *Mesembryanthemum*, with critical remarks." 3. Dr. J. R. Leeson, "Exhibition of Mycetozoa from Epping Forest."

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. N. Collie, "Chemical Studies of Oriental Porcelain." (Lecture I.)

China Society, School of Oriental Studies, Finsbury-circus, E.C., 3.30 p.m. Mr. B. Rackham, "Chinese Influences in the Pottery of the West."

FRIDAY, JANUARY 17...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor Sir James Dewar, "Liquid Air and the War."

SATURDAY, JANUARY 18...Royal Institution Albemarle-street, W., 3 p.m. Rev. Canon J. O. Hannay, "The Irish Literary Renaissance." (Lecture I.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—January 10, 1919.

No. 3452. JANUARY 17, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2.

REGISTERED AS A NEWSPAPER.

Royal Society of Arts

CANTOR LECTURES.

A full list of the Cantor Lectures which have been reprinted from the **Journal** and published separately may be obtained on application to

THE SECRETARY, John Street, Adelphi, London, W.C.

HOWARD AND OTHER LECTURES.

Heavy Oil Engines. Four Lectures. By Captain H. RIALL SANKEY, R.E., M.Inst.C.E. (1912.) Price 1*s*.

Aeronautics. Three Lectures. By Prof. J. E. PETAVEL, D.Sc., F.R.S. (1913.) Price 1*s*.

Surface Combustion. Three Lectures. By Prof. WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S. (1914.) Price 1*s*.

Motor Fuel. Three Lectures. By Prof. VIVIAN B. LEWES, F.I.C., F.C.S. (1915.) Price 1*s*.

Coal and its Economic Utilisation. Three Lectures. By Prof. JOHN S. S. BRAME. (1917.) Price 1*s*.

The Shortage of the Supply of Non-Phosphoric Iron Ore. Two Lectures. By Prof. WILLIAM GEORGE FEARNSIDES, M.A., F.G.S., M.Inst.M.E. (1917.) Price 1*s*.

Journal of the Royal Society of Arts.

No. 3,452. VOL. LXVII.

FRIDAY, JANUARY 17, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 22nd, at 4.30 p.m. (Ordinary Meeting.) COLONEL H. G. LYONS, D.Sc., F.R.S., Acting Director of the Meteorological Office, "Meteorology during and after the War." SIR WILLIAM NAPIER SHAW, D.Sc., F.R.S., Meteorological Adviser to the Government, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

SWINEY PRIZE.

The adjudicators under the will of the late Dr. Swiney are summoned to meet at the house of the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, January 21st, 1919, at 3.30 p.m., to make the award in conformity with the terms of the bequest contained in the will of the testator.

(By Order)
GEORGE KENNETH MENZIES,
Secretary.

NORTH BRITISH ACADEMY OF ARTS, LTD.

It having come to the knowledge of the secretary that circulars, issued by "The North British Academy of Arts, Ltd.," and dated from "Claremont Buildings, Newcastle-upon-Tyne," have been sent to a number of Fellows of the Royal Society of Arts, inviting them to subscribe to the "North British Academy of Arts," he is desired to give notice to readers of the *Journal* that the Society has no connection whatever with this Academy; and Fellows are advised, before giving it their support, to make careful inquiries regarding its activities.

FIFTH ORDINARY MEETING.

Wednesday, January 15th, 1919; SIR WILLIAM M. T. LAWRENCE, Bt., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Baker, Charles John, Shrewsbury.
Barnes, Cecil James, London.
Beardsell, Arthur M., Huddersfield.
Benson, Philip de Gylpyn, B.Sc., London.
Bergesen, Sigval, Stavanger, Norway.
Berry, Charles Walter, London.
Blackmore, Alfred, London.
Borgen, Christian, Stavanger, Norway.
Brain, Sir Francis William Thomas, M.Inst.C.E., Bristol.
Brooke, Herbert, London.
Burt, C. Harley, London.
Carroll, Anthony Joseph, Chester.
Carter, Robert Radcliffe, Walsall.
Connell, John, Glasgow.
Constable, Archibald James, Littlehampton.
Cooke, Harry, Leeds.
Cuttriss, Charles Arthur, Rangoon, Burma.
Dickson, William Collins, Glasgow.
Duveen, Edward J., London.
Elkan, Baron, London.
Evens, Walter, Westcliff-on-Sea.
Falck, Hans L., Stavanger, Norway.
Fogarty, Laurence Francis Alexander, Ruislip.
Fraser, Stewart, Cairo, Egypt.
Hepworth, Cecil M., Walton-on-Thames.
Hill, Norman, Coventry.
Hopkinson, Edward, M.A., D.Sc., M.P., Alderley Edge, Cheshire.
Iden, Walter J., M.I.Mech.E., London.
Lal, Kunwar Nand, Benares, India.
Leaver, Cyril D'Arcy, Harpenden, Herts.
Morton, T. M. Gray, M.I.Mech.E., Wishaw.
Neagle, William, B.Sc., Erith, Kent.
Niblett, Lieut.-Colonel Herbert, D.S.O., Farnham Royal, Bucks.
Palmer, Henry William Hetherington, F.R.I.B.A., London.
Reeves, Arthur William, Birmingham.

Ross, Major Andrew A., R.A.F., London.
Rossiter, Alfred, Luton.
Rush, Lieut. Charles Henry Erskine, A.M.I.Mech.E., M.I.A.E., London.
Ryan, Cecil Godfrey, Tasmania.
Smellie, James, Dudley.
Spalding, Walter, London.
Taylor, Richard Henry, O.B.E., London.
Trench, E. F. C., M.Inst.C.E., London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Allan, James McNeal, Sheffield.
Appleton, Thomas H., J.P., York.
Bailey, William Cooper, Harrogate.
Blee, Edward Lindsay, London.
Channing, Francis Chorley, London.
Ewen, A. J. Clifford, A.R.I.B.A., London.
Hamilton, James, Weybridge.
Hancock, A. J., Luton.
Henderson, John, Glasgow.
Kennedy, Lieut.-Colonel Donald Stuart, R.A.S.C., B.E.F.
Landau, David, New York, U.S.A.
Lewin, Major Herbert William, R.A.S.C., M.A., London.
Miller, Ernest, Karachi, India.
Oakley, Alan James, London.
Poppe, P. A., Coventry.
Rae, John Turner, London.
Richardson, James Alaric, Newcastle-on-Tyne.
Robb, Alexander, Edinburgh.
Sanyal, Jibon Kumar, B.Sc., London.
Shaw, George Frederick, Belfast.
Siddeley, John Davenport, C.B.E., Coventry.
Smith, Major David J., R.A.S.C., O.B.E., London.
Smith, Leslie Tweedie, Westcliff-on-Sea.
Thomas, Hugh Kerr, Buffalo, U.S.A.
Tucker, William Trueman, Loughborough.
Turrell, Charles McRobie, Tinsley, Sheffield.
Yarwood, Douglas, Northwich.

A paper on "English Carpets" was read by Mr. A. F. Kendrick, Department of Textiles, Victoria and Albert Museum.

The paper and discussion will be published in the *Journal* of January 24th.

INDIAN SECTION.

Thursday afternoon, January 16th; Sir Charles H. Armstrong, Chairman, Great Indian Peninsula Railway Company, in the chair. A paper on "The Carriage of Coal by Rail in India" was read by Mr. H. Kelway-Bamber, M.V.O., late Superintendent of Rolling Stock, East Indian Railway.

The paper and discussion will be published in the *Journal* of January 31st.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PHYSICAL CHEMISTRY AND ITS BEARING ON THE CHEMICAL AND ALLIED INDUSTRIES.

By Professor James C. Philip, O.B.E., M.A., Ph.D., D.Sc.

Lecture III.—Delivered December 16th, 1918.

Certain aspects of physical chemistry bearing on technology, more especially equilibrium, velocity and catalysis, have been discussed and illustrated in the previous lectures. On the present occasion an entirely different section of the physico-chemical field is suggested for consideration, viz., the physical chemistry of the absorption of gases and dissolved substances. The object, however, is, as before, to emphasise the bearing of physical chemistry on various industrial processes, and to illustrate the principles of the science by examples taken from technical practice.

The absorption of gases and dissolved substances is an interesting department of physical chemistry, to which much labour has been devoted; the governing principles are in the main well understood and capable of exact formulation. In connection, for example, with the absorption of gases by liquids, there is the generalisation known as Henry's Law, according to which the quantity of a gas taken up by a given quantity of a liquid is proportional to the pressure under which the absorption takes place. The following experimental figures for carbon dioxide in water will serve to illustrate the applicability of the law: P is the pressure (in cm. of mercury) at which the water is saturated; V is the volume of carbon dioxide (measured at 0° C. and 760 mm. pressure) which is absorbed by 1 cub. cm. of water at 15°:—

P	V	$\frac{V}{P}$
69·8	0·944	0·0135
128·9	1·865	0·0144
200·2	2·908	0·0145
236·9	3·486	0·0147
273·8	4·003	0·0146
311·0	4·501	0·0145

Clearly, the ratio $\frac{V}{P}$ is a constant, as required by Henry's Law, and, provided the gas is not highly soluble, the validity of this relationship may be regarded as general.

Under high pressures, therefore, the quantity even of a moderately soluble gas which can be

pressed into a liquid may be very considerable. Everyone is, of course, familiar with the storage of highly soluble gases, such as ammonia and hydrogen chloride, in aqueous solution; but there is an important instance of a similar practice being adopted on the large scale for a gas of medium solubility, viz., acetylene. The adoption of a somewhat exceptional method of storage for this gas is due to the explosive properties which characterise acetylene under pressure, and which, in the early stages of its industrial exploitation, give rise to a number of serious accidents. The compression of acetylene gas by itself, beyond a comparatively low limit, is now indeed legally forbidden in this country.

The gas, however, is fairly soluble in acetone, one litre of this liquid absorbing 25 litres of acetylene at normal pressure; further, in general accordance with Henry's Law, the quantity dissolved increases proportionately to the pressure, so that, under a pressure of 10 atmospheres, 1 litre of acetone takes up about 250 litres of acetylene (measured at 1 atmosphere). The absorption of acetylene by acetone under pressure would therefore provide for the storage of considerable quantities of the gas. The operation, however, of pumping acetylene at 10 atmospheres pressure into a cylinder containing acetone would involve the risk of explosion; since the acetone expands during the absorption, it would be necessary to leave some free space inside the cylinder, and if this were filled with the gas at high pressure, the conditions would be reproduced which led to the abandonment of compression alone as a means of storing acetylene.

This difficulty is surmounted by first filling up the cylinder with a porous material (of 80 per cent. porosity), consisting generally of charcoal alone, or a mixture of asbestos, kieselguhr and charcoal with a suitable cement. A volume of acetone equal to about 40 per cent. of the original cylinder space is added, and the acetylene is then pumped in at about 10 atmospheres. When cylinders are charged in this manner, even up to a pressure of 15 atmospheres, the operation is quite safe, as has been established by recent investigations. By this method of storage 1 cubic foot of cylinder space is capable of holding 100–150 cubic feet of acetylene.

The effect of pressure in increasing the quantity of gas absorbed by a liquid is occasionally utilised in removing carbon dioxide from gas mixtures. A study of the values of the absorption coefficients for the common gases in water (see following table) shows that at the

Temperature.	Oxygen.	Nitrogen.	Hydrogen.	Carbon Dioxide.
0°	·0489	·0239	·0215	1·713
10°	·0380	·0193	·0196	1·194
20°	·0310	·0164	·0182	0·878
30°	·0262	0138	·0170	0·665
40°	·0231	·0118	·0164	0·530

ordinary temperature carbon dioxide is 40–50 times as soluble as hydrogen. If a mixture, therefore, consisting mainly of hydrogen and carbon dioxide, such as is obtained by passing water gas with excess of steam over a heated catalyst, is exposed to water under pressure, the great bulk of the carbon dioxide is absorbed and can be separated from the hydrogen in this way.

It may be of interest to note, in passing, that this influence of pressure on the solubility of gases has been proved responsible for so-called "caisson sickness," or "compressed air illness." It is well known that a man who has been working in a compressed atmosphere, say, in a diving-bell, may develop serious symptoms if decompression is too rapid. These effects have been successfully traced to the presence in the blood, under the high pressure, of excessive quantities of the air gases. These are evolved again when the pressure is released, and may actually give rise to effervescence in the body fluids with possibly serious results. Nitrogen appears to be the chief cause of trouble, since there is in the blood special provision for the reversible chemical fixation of oxygen.

Reference to the figures in the above table, representing the solvent power of water for different gases, shows that the absorption coefficient of oxygen in water is about double that of nitrogen. For equal pressures, therefore, the quantity of oxygen dissolved by a given volume of water is twice the quantity of nitrogen similarly dissolved. In the mixture of oxygen and nitrogen, however, which constitutes air, the partial pressure of nitrogen is about four times that of the oxygen, so that the gas absorbed from ordinary air by water, and recoverable by boiling out the water, is roughly two-thirds nitrogen and one-third oxygen. Even this means a notable enrichment, as regards oxygen, in comparison with ordinary air, and if the enriched air is again submitted to absorption, followed by boiling out, the gas obtained has a still higher proportion of oxygen. The rate of progressive accumulation of oxygen in air, treated alternately in this way to absorption in water and expulsion, is shown in the following table:—

Atmospheric Air.	Oxygen Percentage after successive Absorptions.							
Oxygen	1	2	3	4	5	6	7	8
=21 per cent.	33	48	63	75	85	91	95	97

Patents were actually taken out at one time for the commercial production of oxygen on the basis just described. These, however, do not appear to have led to any serious practical developments.

Another direction in which the difference in solubility of gases has been utilised to effect their separation, is in the working up of ammoniacal gas liquor. In the crude state this contains as main constituents ammonia, sulphuretted hydrogen, and carbon dioxide, with, of course, the chemical compounds formed by their combination, and some other substances which are not of interest in the present connection. As a preliminary to the distillation of the liquor, it is desirable to remove as much as possible of the sulphuretted hydrogen and the carbon dioxide without, at the same time, incurring any serious loss of ammonia. This may be effected by a process, such as that patented by Hills in 1868, based on the fact that sulphuretted hydrogen and carbon dioxide are much less soluble in water than ammonia. In the gas liquor at ordinary temperatures, there are, of course, ammonium sulphide and carbonate, but with rising temperature these will dissociate more and more, so that if a liquid containing the three gases named is heated, it will give up the major part of the sulphuretted hydrogen and the carbon dioxide, and will retain the great bulk of the ammonia.

In the plants in which this process has been introduced, the crude liquor is run in at the top of a tower—the "dissociator" or "preheater"—and flows from one to another of a series of steam-heated trays, the temperature being highest in the bottom or terminal tray. By such treatment the liquor loses the bulk of its acid constituents, and at the outlet of the apparatus consists mainly of caustic ammonia. In a recent discussion of this matter by Parrish, it was shown that, given efficient working of the dissociator, a gas liquor containing about 1·7 per cent. ammonia could have its carbon dioxide content reduced from 1·2 per cent. to 0·12 per cent., and the sulphuretted hydrogen from 0·35 per cent. to 0·04 per cent.

The relation between a gas and an absorbent liquid at any given temperature, as exemplified by the cases just quoted, is a comparatively simple one; it has been described as based on proportionality between the pressure and the quantity of gas dissolved. If it is borne in mind that gas pressure is proportional to the *concentration* of the gas, an alternative method of formulating Henry's Law presents itself, involving the concentration of the gas in the gas phase (c_g), and its concentration in the liquid phase (c_l). Supposing equilibrium between a gas and a liquid has been attained by shaking the two sufficiently long together, then Henry's Law requires that the ratio $\frac{c_l}{c_g}$ = const., whatever be the individual values of c_l and c_g.

Passing now to the absorption of gases by solid substances, it is found that the relation between the concentration of the gas in the gas phase (c_g) and that in the solid phase (c_s) is less simple than is the case with the corresponding ratio of distribution in the system gas + liquid. As a general rule, if an absorbent solid is exposed to a gas at a given temperature and steadily increasing pressure, the quantity of gas taken up by the solid increases regularly, but more slowly than the pressure rises. It is found that the relation between c_g and c_s can, in many cases, where the factor of chemical action in the ordinary sense is absent, be represented by a formula of the type $\frac{c_s}{c_g^{\frac{1}{n}}}$ = const., where n is a number greater than unity.

An instance of this kind is furnished by the equilibrium between carbon and carbon dioxide, investigated by Travers. The graphs reproduced (by kind permission of the Royal Society) on page 125 show that at any given temperature an increase of pressure results in increased absorption, but that the quantity of carbon dioxide taken up increases more slowly than the pressure.

Further, the applicability of the formula $\frac{c_s}{c_g^{\frac{1}{n}}}$ = const., may be illustrated by the figures recorded at 0° in the course of the same research. In the following table, which embodies these results, P is the equilibrium pressure, stated in mm. of mercury, while c_s represents the percentage by weight of the carbon dioxide in the carbon; plainly, P may be taken as expressing c_g:—

Absorption of Carbon Dioxide by Charcoal.

P mm.	c_s.	$\frac{c_s}{\sqrt[3]{P}}$
4·1	0·38	0·24
25·1	0·77	0·26
137·4	1·45	0·26
416·4	2·02	0·27
858·6	2·48	0·26

So far as these results at 0° are concerned, it is clear that the relation between the concentrations of carbon dioxide in the gas phase, and the solid phase, is satisfactorily expressed by the formula $\frac{c_s}{c_g^{\frac{1}{n}}}$ = const., where n = 3. At higher

temperatures n appears to have a smaller value.

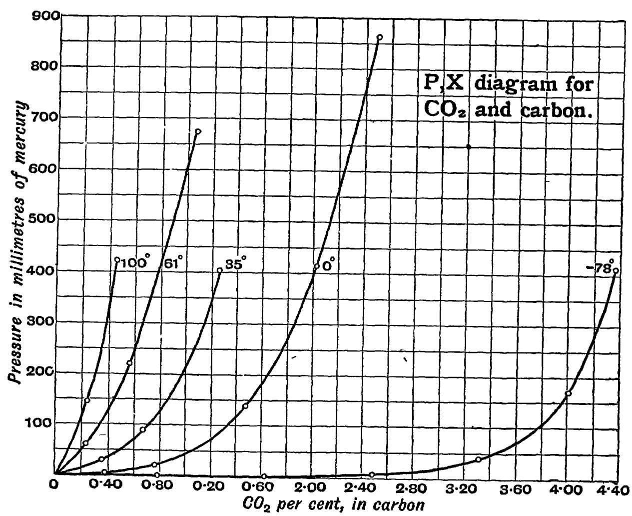
The contrast between the formulæ $\frac{c_l}{c_g}$ = const., and $\frac{c_s}{c_g^{\frac{1}{n}}}$ = const., applicable respectively to the equilibria between (1) a gas and a liquid, and (2) a gas and a solid, suggests inquiry as to the cause of this difference. A consideration of the facts makes it highly probable that, whereas the distribution of a gas dissolved in a liquid is uniform, the gas which is taken up by a solid is not evenly distributed throughout the mass of the solid. In the case of a solid, the gas can reach the interior of the particles only by a process of diffusion, and this fact renders it extremely likely that the distribution of the gas in the solid phase, in its early stages at least, is non-uniform. Light is thrown upon this matter to some extent by taking into account the time-factor in relation to the absorption of gases by solids. The salient points in this connection may best be emphasised by reference to McBain's experiments on the absorption of hydrogen by charcoal at the temperature of liquid air.

This work has definitely proved that the process of absorption in its first stage is extremely rapid, but that the end of this first stage does not coincide with the final equilibrium. The pressure, which drops suddenly on exposure of the gas to the cooled charcoal, enhibits thereafter a slow decrease extending over a long period. This important feature of the absorption is brought out by the following record, referring to an experiment in which hydrogen at 600 mm. pressure was brought into contact with gas-free charcoal at room temperature, the bulb containing the latter being then immersed in liquid air, and readings of the pressure being taken thereafter from time to time :—

Time.	Pressure.
2 min.	1·57 mm.
4 „	1·47 „
6 „	1·39 „
8 „	1·33 „
11 „	1·22 „
40 „	1·20 „
2½ hours	1·12 „
9 „	0·91 „

The sudden fall of pressure from 600 mm. to between 1 and 2 mm. shows that the great bulk of the gas is absorbed with great rapidity; but this first short stage is clearly succeeded by a secondary and very slow absorption, lasting over many hours. Such a record, reinforced by other experiments on similar lines, furnishes the basis for the view that, when hydrogen or any other gas is brought in contact with charcoal, there is first an absorption effect confined practically to the surface layers, the accessibility of these layers accounting for the rapidity of this absorption, and that, secondly, a gradual penetration of the charcoal particles by the gas takes place; the latter, being a diffusion process, is naturally slow.

If the dual character of the phenomenon of absorption of a gas by a solid is admitted, it is convenient to distinguish between the surface effect and the subsequent penetration of the gas into the mass of the charcoal. At the present time it is customary to describe the first phenomenon as "adsorption" and the second as



"absorption," the latter term suggesting that the process is analogous to the dissolving of a gas in a liquid, and probably leads up to a state of uniform distribution in the interior of the solid. As a term covering both processes, the word "sorption" is sometimes employed.

This view of the dual nature of the sorption of a gas by a solid is strengthened by experiments in which a sample of charcoal, previously rendered gas-free by evacuation, is exposed for a brief space to a high hydrogen pressure, and subsequently to a considerably lower pressure. The brief exposure to the high pressure is sufficient to allow equilibrium to be attained at the surface, but too short to permit more than the commencement of the slow diffusion towards the interior. Consequently, when the gas pressure is reduced, the surface is in a state of supersaturation, and some gas is therefore liberated, leading to a rise of pressure. Gradually, however, the diffusion of the gas into the interior makes itself felt, and the loss of gas in the surface layers which results from this diffusion has to be made good by the adsorption of more gas—*i.e.* the pressure begins to fall. This is a description of what actually happens under the conditions suggested, as appears from the following record:—

	Time.	Pressure.
Added 71·2cc. hydrogen	0–½min.	—
Removed 25·1cc. ,,	3–11¼ ,,	—
	13 ,,	8·70mm.
	14½ ,,	8·78 ,,
	16 ,,	8·80 ,,
	18 ,,	8·82 ,,
	20 ,,	8·75 ,,
	27 ,,	8·64 ,,
	42 ,,	8·56 ,,
	105 ,,	8·43 ,,
	285 ,,	8·38 ,,

The evidence just submitted as to the respective *rôles* of the surface effect and the diffusion effect is confirmed by experiments in which charcoal, fully saturated, is robbed of its surface gas by a short evacuation, and then gas is admitted at an intermediate pressure. At this stage the interior, from which the gas can escape only slowly, will be supersaturated, whilst the surface is unsaturated. Accordingly it is found in this case that the pressure first falls and then rises.

The phenomena attending the sorption of gases by charcoal have been discussed in some detail, since the relationships which prevail here are generally characteristic of gas + solid systems, excluding those cases in which chemical action may occur between the gas and the solid. Sorption of gases by solids is quite a common occurrence, and in this category there may be placed numerous observations with a practical and, in some cases a technical, bearing. There is, for example, the application of cooled charcoal in the production of high vacua, a method employed in the first instance by Dewar, who drew attention to the enormously increased absorptive power at low temperatures. This important fact is emphasised by the following figures:—

	Volume of gas absorbed by 1 gram. charcoal at 0° C.	at – 185° C.
Hydrogen . .	4 cub. cm.	139 cub. cm.
Nitrogen . .	15 ,, ,,	155 ,, ,,
Oxygen . .	18 ,, ,,	230 ,, ,,

Other phenomena which are closely related to the gas + solid equilibrium are the occlusion of gases by metals, the retention of moisture by glass surfaces, and the variation in the moisture content of textile fabrics with the humidity of the atmosphere. One isolated case of adsorption that is perhaps worth mentioning by way of qualitative illustration occurs in connection with the determination of moisture in coal. If an attempt is made to estimate the moisture from the loss of weight on heating to 100–110°, it will be found that the weight of the material, after an initial decrease, will subsequently increase, owing to the oxidation of a small quantity of the coal substance, and the retention, by adsorption, of the gas produced.

A very important application of sorption on a large scale has been made recently in connection with the protective measures taken against poison gas during the war. All the belligerent armies introduced some form or other of gas-mask, and in every case reliance was placed to a considerable extent on the power of charcoal to remove noxious and lethal gases from the air inhaled by the wearer of the mask. Much research was carried out with the object of preparing charcoals of maximum effectiveness, and it is a matter for satisfaction that British chemists were able to produce in the requisite large quantity a charcoal of very high sorbent power.

In the foregoing paragraphs reference has been made repeatedly to charcoal as a sorbent for gases, and to some of the quantitative aspects of this phenomenon, but it ought to be pointed out that the actual amount of sorption varies in an extraordinary degree with the character and previous history of the charcoal. As in heterogeneous catalysis, in which

certainly surface concentration on the catalyst plays a prominent part, so with the sorption of gases by solids, the condition of the surface is a factor of prime importance. Not only does the sorbent power of the charcoal vary with the source of the material, but samples of the same charcoal may differ in a remarkable degree according to the treatment they have received. Thus precise knowledge is still lacking on many points connected with the sorbent power of wood charcoal, as, for example, on the influence (1) of the nature of the wood from which the charcoal is derived; (2) of the temperature of carbonisation; (3) of the duration of heating.

As an example, however, of the notable extent to which the sorbent power of a wood charcoal may be influenced by the conditions under which it has been prepared, the following figures may be quoted. They refer to experiments in which a given quantity of the charcoal was treated twice or thrice in succession with six litres of air carrying always the same amount (about 1 per cent. by volume) of an absorbable gas. After each treatment the proportion of the gas retained by the charcoal was found by estimating the quantity which had escaped sorption. The three charcoals, A, B and C, for which details are given, were originally produced in the same batch, but B was a portion of A subjected to a further four hours' heating, and C was a portion of B subjected to a further two hours' heating:—

	Percentage of gas retained by the charcoal.		
Charcoal.	Dose 1.	Dose 2.	Dose 3.
A . . .	78	5	–
B . . .	100	20	–
C . . .	100	100	97

It is clear that continued heat treatment leads to a distinct improvement of the charcoal, so far as its sorbent power is concerned.

The phenomenon to which the name "adsorption" has been given is exhibited, not only by a solid in contact with a gas, but also in numerous instances by a solid in contact with a solution. The dissolved substance present in the solution is partially removed by shaking with the solid, the actual amount taken up by the latter increasing with the concentration of the solution. If c_s represents the concentration of the solute in the solid, and c_l its concentration in the solution after equilibrium has been attained, it is found in many cases that $\frac{c_s}{c_l^{\frac{1}{n}}} = \text{const.}$, this adsorption equation being identical in form with the one already shown to be applicable in gas + solid systems. Before, however, one or two special cases of interest are considered, it is desirable to inquire whether sorption of a dissolved substance by a solid is also of a dual character, whether there is absorption as well as adsorption.

Now there are undoubtedly cases where the removal of the dissolved substance by the solid absorbent continues over a long period, clearly indicating that the initial surface adsorption is followed by a slow diffusion of the dissolved substance into the interior of the absorbent particles. An instance of this sort of thing is supplied by Davis' experiments on the effect of shaking carbon with solutions of iodine in various organic solvents. In one set of experiments in which animal charcoal was shaken with a toluene solution of iodine, it was found that at three, ten, and twenty-four days from the start the weights of iodine retained per gram of charcoal were 0·328, 0·339, and 0·386 gram respectively. In this case, therefore, a gradual penetration of the iodine into the charcoal appears to follow the rapid initial surface adsorption.

In experiments, however, carried on for a short time only, this slow diffusion scarcely makes itself felt, and a practical equilibrium is reached, which, it is noteworthy, can be attained from both sides. In illustration of this some figures may be quoted which were recorded in a study of the sorption of acetic acid by carbon. One gram of carbon was shaken for 20½ hours with 100 cub. cm. of a 0·0688 N solution of acetic acid; by this time equilibrium was established, and the acid solution was now 0.0608 N. In another experiment, one gram of the same carbon was shaken for 21 hours with 50 cub. cm. of a 0·1376 N (= 0·0688 × 2) solution of acetic acid; 50 cub cm. of water were then added, and the mixture further shaken for an hour, at the end of which time it was found that the acid solution was 0·0606 N. This is practically the same value as in the first case, showing that the same equilibrium is reached when the carbon is charged directly with the acid, as when a slightly overcharged carbon is deprived of part of its adsorbed acid.

As already stated, the amount of dissolved substance adsorbed by the solid varies with the concentration of the former in the solution, and, as illustrating the nature of this relation between c_s and c_l, some further figures for carbon and acetic acid solutions deserve attention.

In the following table c_l represents the equilibrium concentration of the acetic acid in the solution, stated in millimolecules per cubic

cm.; c_s represents the corresponding equilibrium concentration of the acetic acid in the carbon, stated in millimolecules per 1 gram of the solid:

Adsorption of Acetic Acid by Carbon.

c_e.	c_s observed.	c_s calculated.
0·0181	0·467	0·474
0·0309	0·624	0·596
0·0616	0·801	0·798
0·126	1·11	1·08
0·268	1·55	1·49
0·471	2·04	1·89
0·882	2·48	2·47
2·79	3·76	4·01

Inspection of the table shows that the amount of acetic acid taken up by the carbon increases much more slowly than its concentration in the solution, and in this respect the adsorption of dissolved acetic acid by carbon, and the adsorption of carbon dioxide gas by the same substance are similar. The parallelism, however, goes further, for the relation between the acetic acid in the solution and in the carbon can be represented by the adsorption formula $\frac{c_s}{c_l^{\frac{1}{n}}}$ = const. The applicability of this formula to the case under consideration is proved by the figures in the third column of the above table. These are the values obtained by taking the constant = 2·606, and n = 2·35, and inserting for c_l the successive figures tabulated in the first column.

So far, carbon alone has figured as the adsorbent solid, and it may not be without interest to quote some results showing that similar relationships prevail also when other substances than carbon are employed. For this purpose reference may be made to Georgievics' experiments on the distribution of hydrochloric acid between water and wool. Lots of 5 grams of carefully cleaned wool were immersed in 250 cubic cm. of hydrochloric acid solutions of different strengths, and shaken up frequently over a period of at least 24 hours. The concentration of the hydrochloric acid left in the solution was then determined by titration. The figures following will show the kind of result obtained:—

Gm. HCl taken.	Left in solution. c_l.	Retained by wool. c_s.	$\frac{c_s}{c_l}$.	$\frac{c_s}{c_l^{\frac{1}{5}}}$.
0·25	0·152	0·098	0·64	·143
0·5	0·381	0·119	0·31	·144
1·0	0·863	0·137	0·16	·141
2·0	1·84	0·16	0·087	·142
3·0	2·83	0·17	0·060	·138

Here we have the characteristic feature of adsorption from solutions, viz., that the removal of the dissolved substances from the dilute solutions is relatively more complete than from the concentrated solutions. Further, the usual adsorption formula is applicable to the relation between wool and hydrochloric acid solutions, as shown by the practical constancy of the figures in the last column. The value of the simple ratio $\frac{c_s}{c_l}$, on the other hand, changes rapidly.

The general features of the adsorption of a dissolved substance by a solid having been outlined in sufficient detail, it now remains to draw attention to those technical processes in which adsorption plays a *rôle*. Most prominent in this connection, perhaps, is the operation of dyeing. There is much evidence to prove that in many cases the deposition of a colouring matter from the dye-bath on animal or vegetable fibres is closely analogous, in its first stages at least, to the process of adsorption, although no doubt other factors, to which reference will be made, are also operative.

One case in which the relation between fibre and colouring matter is to be regarded as an adsorption equilibrium may be discussed in some detail, viz., the dyeing of silk by picric acid. Walker and Appleyard have made experiments in which 2 grams of silk were heated for 40 hours at 60° with 100 cubic cm. of picric acid solution of known concentration. At the close of this period, which preliminary work had shown to be sufficient for the attainment of equilibrium, the acidity of the solution was determined by titration. Results obtained with solutions of different concentration are shown in the table below:—

Mg. acid in 1 cc. solution.	Mg. acid in 1 gram silk Found.	Calculated.
0·064	13	13
0·12	17	16
0·59	27	29
0·98	37	35
1·98	44	46
2·93	54	53
5·00	64	64
7·00	75	73

The relation between the adsorbed acid (c_s) and the acid remaining in solution (c_l), is satisfactorily represented by the formula $\frac{c_s}{\sqrt[2\cdot7]{c_l}} = 35\cdot5$. This is proved by the agreement of the figures in the second and third columns of the table, those in the third column having been calculated by the formula from the corresponding values of c.

Another significant point established in the course of this investigation is that the adsorption equilibrium between silk and picric acid is reversible. It can be shown that for a given final concentration of picric acid in the solution, the concentration in the silk is the same whether the starting-point is silk free from acid, or silk which has been overcharged with the dye and is brought to equilibrium by digesting with water.

Later work has shown that the relation of silk, wool, and cotton to aqueous solutions of many dyestuffs, such as crystal violet, patent blue and new magenta, is in all points analogous to the relation between charcoal and these dyes, or between silk and picric acid. That is, the equilibrium which is reached is a reversible one, and the removal of the colouring matter from solution is in each case in harmony with the adsorption formula $\frac{c_s}{c_l^{\frac{1}{n}}} = \text{const.}$ Such a result is opposed to the solid solution theory of dyeing, for this supposes a uniform distribution of the dye in the fibre, and requires that the relation between c_s and c_l shall be that expressed in Henry's Law, viz.: $\frac{c_s}{c_l} = \text{const.}$ At the same time it should be pointed out that in some cases, with very dilute solutions, a distribution of dyestuffs between water and wool in accordance with Henry's Law has actually been observed.

Although it may be taken as established that in the majority of instances the process of deposition of a dye on a fibre is essentially an adsorption phenomenon, it is clear that this does not provide a complete account of the process of dyeing. The relation between a dye and the fibre cannot be reversible in every case, otherwise it would not be possible to procure a fast colour; either the process must be irreversible in some cases, or the adsorption of the dye by the fibre is followed by some other change, which leads to the fixation of the dye. Frequently, without doubt, such fixation is based on chemical action of some sort, but a discussion of this aspect of the theory of dyeing lies outside the scope of these lectures.

In addition to charcoal and the common animal and vegetable fibres, another material of technical importance, from the present point of view, is fuller's earth. This is employed mainly in decolourising both mineral and fatty oils, and its bleaching action is due to adsorption, in the sense already explained. Fuller's earth is very effective, too, in removing various substances from aqueous solution, notably basic dyes and alkaloids, and methylene blue may conveniently be employed for the purpose of estimating the adsorbent power. Examination of numerous samples of fuller's earth from different sources has shown that in general there is a parallelism between the amounts of methylene blue and quinine sulphate adsorbed from solution by the various samples. In the case of the most effective material, 100 grams of the earth adsorb 15–16 grams of quinine sulphate or methylene blue, whilst other samples of the same weight may take up as little as 1–2 grams. It is only the free base which is adsorbed by the fuller's earth, and with both quinine sulphate and methylene blue the acid is liberated and remains in the solution. A similar observation has been made in connection with the adsorption of certain basic dyes by wool, carbon, or even pure cellulose.

Just as the adsorptive power of fuller's earth depends largely on its source and on the treatment it has received, so the efficiency of other adsorbent materials is sensitive to differences in the conditions to which they have been exposed. The case of charcoal may be cited in this connection. Opinions differ as to how far it is possible to modify the adsorptive power of a given charcoal by chemical or physical treatment, but there are undoubtedly some cases where such modification can be achieved without difficulty. It has been found, for example, that, by merely heating a wood charcoal for longer periods, its power of extracting methylene blue from aqueous solution increases in a notable degree. This appears from the following record of results obtained with a wood charcoal, 0·5 gram of which was in each case shaken for three hours with 100 cubic cm. of a given methylene blue solution:—

	Per cent. dye removed from solution.
Original charcoal	17·7
Heated 3 hours	24·4
,, 4 ,,	28·3
,, 6 ,,	33·7
,, 9 ,,	42·5
,, 18 ,,	51·8
,, 24 ,,	60·3

The precise factors which are responsible for such an increase in the efficiency of charcoal are not yet clearly understood.

An interesting attempt to utilise the adsorptive power of different clays as a measure of their plasticity has been made some time ago by the United States Geological Survey. This attempt is based on the fact, to which, if time permitted, detailed consideration might be

given, that the property of adsorption is characteristic, in a quite special degree, of colloids. This being so, it is found permissible to regard the power of clays to adsorb certain dyes as determined by the colloidal matter present in the clays, and hence if a series of clays are arranged in the order of their adsorptive power, they will be in the order also of their colloid content. Further, the plasticity of a clay appears to be determined mainly by its colloid content, so that measurements of the adsorptive power of clays for, say, malachite green, furnish a means of approximately classifying them in the order of plasticity.

Another technical application of adsorption, which is worthy of notice, is found in the refining of raw sugar. One of the stages in this process is the filtration of the hot sugar liquor, already freed from suspended matter, through charcoal, generally animal charcoal, in order to remove colouring principles and other dissolved impurities. These impurities are adsorbed by the charcoal, and if the latter is efficient the filtered liquid should be entirely free from colour or nearly so. From time to time the charcoal is thoroughly washed out and transferred to kilns to be reburned.

Now, while the function of the charcoal is to remove impurities, it should not be forgotten that it adsorbs sugar also. In this connection it is perhaps worth while making the point that when a sugar solution is shaken with charcoal a genuine equilibrium is reached; it is not a case of the progressive destruction of the sugar. This statement is justified by such results as those quoted in the following table, which represents the change in the rotation of a glucose solution, containing 17·1 grams of the sugar in 100 cubic cm., when shaken with 5 grams of animal charcoal:—

	Rotation.
Original solution	22·90°
Shaken for 30 min. . . .	20·94°
„ „ 1 hour . . .	20·95°
„ „ 3 hours . . .	20·88°
„ „ 30 „ . . .	20·89°

The figures show very clearly that after the first rapid adsorption there is no further change in the concentration of the solution—*i.e.* a genuine equilibrium is established between the charcoal and the glucose solution. The actual amount of a sugar retained by animal charcoal will of course vary, in accordance with the principles of adsorption, with the concentration of the sugar solution. This point may be enforced by reference to experiments in which 100 cubic cm. of cane sugar solutions of different strengths were shaken with 5 grams charcoal until equilibrium was reached. The results are shown below:—

Gm. sugar in original solution.	Gm. sugar in solution at equilibrium.	Gm. sugar adsorbed.
3·44	2·24	1·20
8·73	7.29	1·44
17·47	15·91	1·56

Finally, a brief reference may be made to the significance of adsorption in connection with soil problems. It has long been known that certain soluble salts, such as ammonium or potassium sulphate, are not washed out of the soil by rain to any extent, but are retained by the soil and are available for the nutrition of the plant. Later and more definite experiments have demonstrated that when a solution of ammonium sulphate is shaken with soil, the ammonia is retained by the soil and an equivalent quantity of lime passes into solution. This resembles a purely chemical interaction, and the phenomenon was for some time interpreted in this sense. Another view, however, may be taken of the matter—a view which is based on van Bemmelen's investigations of the removal of dissolved substances from solution by colloidal gels, such as silica and alumina, and which regards soil absorption as a manifestation of the colloidal properties of soil. It can, in fact, be shown that the removal of dissolved substances by soil from solutions of different concentrations takes place in harmony with the adsorption formula, to which frequent reference has been made above.

It may appear strange that, if the phenomenon is really one of adsorption, the removal of one base from solution should be accompanied by the displacement of some other base from the soil in equivalent quantity. It appears, however, that, as in the case of the adsorption of basic dyes by fibres and other colloids, the acid radicle is in general not adsorbed: the acid remains in solution and then dissolves out some of the bases from the soil.

Organic substances also are adsorbed by soils to a notable extent, but the phenomenon is not accompanied by any exchange of the kind just described. As Russell has pointed out, practically the whole of the organic matter added to the soil by plant residues or manure remains near the surface, unless mechanically displaced. The adsorption of organic matter by soil finds application in the purification of sewage by land treatment.

The significance of adsorption in connection with a number of technically important processes is apparent, and need not be further emphasised. The physico-chemical investigation of this phenomenon, as of those connected with equilibrium, reaction velocity, and catalysis, has undoubtedly led to a clearer apprehension and a more intelligent handling of numerous operations in the chemical and allied industries. This justifies the confidence that the extended application of the quantitative methods of physical chemistry in connection with technical processes is bound to make for efficient working and rational control.

INDUSTRIES AFTER THE WAR.

IV.—TEXTILES (*continued from p.* 104).

Hosiery.

As understood by the trade, "hosiery" embraces a very large number of articles besides hose, *e.g.* undergarments, fabric gloves and scarves. More than three centuries old—it is mentioned in one of the earlier Acts of Queen Elizabeth's reign—the industry in former times, and before Nottingham and Leicester attained their pre-eminence in the fabrication of this class of goods, was centred around London and at the small Surrey town of Godalming, then also noted for its cloth.

In 1589 a Nottinghamshire clergyman, the Rev. William Lee, invented the celebrated stocking-frame, which mechanically produces the looped stitch, and in 1758 a Derbyshire farmer, Mr. Jedediah Strutt, grandfather of the first Lord Belper, adapted the apparatus to the production of ribbed work. Lee's great services brought him little reward. Strutt was more fortunate. By his invention he laid the foundation of a great business. The peerage given in 1856 to his descendant has been well described as "a direct tribute to the industrial interests of the nation."

In 1907, according to the Census of Production, there were 39,971 hosiery workers in the country, the majority being women and girls. Some forty years ago the trade was reported to be giving employment to 150,000 persons. The industry then was largely domestic, frames being hired out to operators. Now, under the factory system, with its means of rapid and manifold production one girl can tend three or four machines, each of which will turn out 500 pairs of stockings per week.

It would be interesting to know the present annual value of the entire output of the Midland factories. The Board of Trade Committee, in referring to the extent of the trade, confines its figures to exports. In 1913 the exports of British textiles of all kinds, at the lower prices then prevailing, realised the enormous sum of £200,000,000. From the following figures it will be seen that "hosiery" occupied the sixth place on the list:—

	£
Cotton	127,000,000
Wool	38,000,000
Linen	9,463,000
Jute	5,339,000
Lace	4,108,000
Hosiery	2,671,000
Silk	2,096,000
Carpets	1,537,000

In a previous article (pp. 102-104) it was shown that Nottingham fancy lace has been ousted from the world's markets by German productions. A similar thing has happened with cotton hosiery and fabric gloves. Whilst British woollen hosiery at the outbreak of war was holding its own at home and abroad, British cotton hosiery and fabric gloves were hopelessly beaten by Germany, which had obtained a practical monopoly in these goods, which they were able to sell at very low prices. German manufacturers had specialised in cotton hosiery, their success being based upon the huge scale of their outturn, although they were largely dependent upon England for the requisite cotton yarns. In 1913 about 40,000,000 lb. of cotton yarns valued at £4,000,000 were exported from Lancashire to Germany. The superiority of the Germans in hosiery finishing is said to be due rather to their chemical than to their mechanical skill—the old story. "We are informed," says the Committee, "that some years ago they (the German producers) discovered a process of dyeing black on cotton, known as the Hermsdorff process. This process not only produced a very permanent black, but also imparted a soft, velvety finish to the goods. As a result of some chemical action which is thought to take place during the operation of dyeing between the dyestuff and the cotton fabric, the latter appears to gain weight and to assume a more substantial appearance." For a long time efforts to establish a similar process in this country met with no success, but the Committee understands that some British firms are in possession of the secret and that the process is now being used in this country. Full advantage of the situation created by the stoppage of German imports, and the necessity placed upon our manufacturers of devoting their operations mainly to war contracts, was promptly taken by America and Japan. The following table shows the rise in the exports of cotton hosiery from those two countries in the first two years of the war, the figures, it is needless to point out, being swollen by the abnormally high values then and now prevalent:—

FROM THE UNITED STATES.

Year.	Stockings and Socks.	Other kinds.
	£	£
1913 . .	6,286	227,937
1915 . .	262,082	1,673,160
1916 . .	699,346	1,264,629

FROM JAPAN.

Year.	Stockings and Socks.	Other kinds.
1913 . .	*	26,936
1915 . .	*	210,299
1916 . .	8,600	1,228,797

* Insignificant.

Since the war the Americans have also competed with us in Canada and the Japanese in India. On the other hand, our orders from France, Norway and Denmark have increased.

The export of British-made fabric gloves had become quite negligible before the war, while in 1912 the German export trade in these articles amounted to upwards of a million and a half pounds sterling. Glove-making in Germany, it appears, is largely a "home industry" carried on in the Chemnitz district, and labour is stated to have been about 25 per cent. cheaper than in the United Kingdom. The cost of labour represents about one-third of the value of the finished article, and the difference referred to naturally gave the Germans a marked advantage. A further fact in their favour is that most German hosiery manufacturers combined all their industrial processes in one business, whilst in this country the weaving, dyeing and finishing were carried on by separate firms. Many British firms have, however, seized the opportunity afforded by the cessation of German competition and the prevalence of high prices to reorganise their methods, so as to reduce the cost of production, and great progress is reported.

Reference is made above to the large supplies of fine yarn sent from Lancashire to Germany in past years. The Committee mentions that considerable uneasiness is felt by English cotton-spinners as to the disposal of their products if the German demand is restricted in future. It is to the development of the hosiery trade in the United Kingdom that (the Committee was informed) spinners must look with most hope. But the experts who gave evidence were practically unanimous in maintaining that if a cotton hosiery industry upon a sufficiently large scale is to be built up here some measure of protection will have to be afforded to British producers in their own market. *Inter alia*, the exclusion, during reconstruction, of all hosiery of enemy origin, followed by a duty of 50 per cent. *ad valorem* upon German goods, was suggested. A large majority of the witnesses were in favour of a tariff for all imported hosiery, glove fabrics and fabric gloves, with concessions in favour of the Allies, and possibly of neutrals prepared to afford reciprocal treatment.

As a result of the war, the British hosiery industry has been greatly handicapped by the lack of dyestuffs. The shortage of hosiery needles has also caused much inconvenience. There are, it is explained, two kinds of hosiery needles—the bearded and the latch. The former have always been produced in adequate quantities in the United Kingdom, but before August, 1914, supplies of the latter came almost exclusively from Germany. Efforts have been made to establish the manufacture of latch needles in this country, but progress has been slow, owing to difficulty in securing skilled labour. Government assistance to the makers of hosiery needles, as well as to the dye-making industry, is considered essential if German supplies are to be dispensed with.

THE COAL MINES OF MACEDONIA.

In Macedonia coal in abundance is found in the valleys, appearing above the surface in many places. In the valley of Kossovo, in the neighbourhood of Sibovtzi and Hade, along the Sitnitza River to the south-west of the town of Prishtina and around the village of Shashkovitza, in the northern extreme of the valley to the south-west of Prishtina, the coal deposits are extensive and valuable. The layers are usually about $4\frac{3}{10}$ ft. thick, with a north-easterly direction, almost horizontal, and showing above the ground, in some places, the distance of a kilometre. The Serbian railways were formerly supplied with coal from this particular region. In the basin-like valley of Prizrend coal also appears above the ground in layers averaging 2 ft. thick. The same condition is found in the narrow valley of Piscupshtina River in the environs of the villages of Lukovo, Perezi, and Berovo up to Mercybey in the Ochrida district. In these particular localities the surface layers average in thickness from $\frac{3}{4}$ of a foot to 4·35 ft., but this coal has only a local value, as it is far from the railway.

In the Pelagonian Basin coal is also found in the outskirts of Seletchka mountain towards Prilep, Suhodol, and Jivonia. On the Tcherna River, in the near distance, are layers from 3·25 to 6·75 ft. thick.

While peasants were recently digging a well near the village of Tzaridvor, in the Ressen Valley, coal was found 16 ft. from the surface; the vein, however, was but 2·25 ft. in thickness. Enough coal has already been found in this particular locality to supply the entire neighbourhood, and in all probability there are other and greater deposits not yet located.

In the districts around Skopie coal is found in quantity and of very good quality, the veins being from 2 to 3 ft. in thickness. In the vicinity of Bardovtzi to the west of Skopie, the same kind of bituminous coal is found; as also in the neighbourhood of Kitchevo.

Macedonia is undoubtedly rich in coal, but proper measures have never been taken to locate the deposits, or to work intelligently the veins. In the opinion of the United States Consul-General at Sofia, Macedonia under friendly rule will present a most promising field for the investment of capital and the development of its natural wealth.

GENERAL NOTES.

Nettles a Future Source of Textile Fibre.—The search made necessary in Germany by the war for a substitute for cotton has revealed possibilities which may be made actual in the near future. The common stinging-nettle is likely to become an important factor in agriculture and in the development of the textile industry. Among the many fibrous plants experimented with, the nettle alone has fulfilled all the conditions of a satisfactory source of textile fibre. Investigations and practical tests, made in 1916 at Brünn and Reichenberg, confirm the hopes raised concerning the possibilities to be realised in nettle fibre. There exists now in Germany, according to the *Technische Blätter*, a "Nettle Cultivation Company." The price of 10 Marks per 100 kilograms of air-dried nettle stalks, which can, it is said, be paid, ensures sufficient gain to the growers, while the cost of preparation is not high. In 1915, 1·3 million kilograms of this material were collected in Germany, a quantity which increased to 2·7 million kilograms in 1916; and this without any attempt at systematic cultivation. Thus the capabilities of the plant have been thoroughly tested. From the standpoint of the factory it is affirmed that goods woven from this fibre are, for most uses, equal to cotton goods. Hence for middle Europe at least a large and increasing use of nettle fibre seems assured.

Paper-making in the Transvaal.—The establishment of a paper industry in the Transvaal, says *United Empire*, is now an accomplished fact. It has been decided to start with the production of cardboard only, for which there is a big demand in the Union; but, as the industry progresses, the manufacture of brown paper, brown boards, and many other cognate commodities will be undertaken. The plant, which is of an extensive character, is being manufactured locally. Waste paper, rags, sacking, and twine will be used as raw material at first, but as time goes on it is intended to include a greater proportion of natural products—such as fibre, spent wattle-bark, etc. The enterprise is all the more interesting in view of the fact that it is probably the first real attempt in the Union to produce this article on a commercial scale.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

January 22.—Colonel H. G. Lyons, D.Sc., F.R.S., Acting Director of the Meteorological Office, "Meteorology during and after the War." Sir William Napier Shaw, D.Sc., F.R.S., Meteorological Adviser to the Government, will preside.

January 29.—Frederick William Keeble, C.B.E., M.A., Sc.D., F.R.S., Director of Horticulture, Food Production Department, "Food Production by Intensive Cultivation." Lord Lambourne, C.V.O., will preside.

February 5. — Edward Carstensen de Segundo, A.M.I.C.E., M.I.Mech.E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes." Lord Lamington, G.C.M.G., G.C.I.E., will preside.

February 12.—Sir Frank Heath, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

February 19.—John Francis Crowley, D.Sc., A.M.I.E.E., "The Use of Electricity in Agriculture in Germany." Sir John F. C. Snell, M.Inst.C.E., will preside.

February 26.—W. L. Hichens (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry."

March 5.—B. D. Porritt, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

March 12.—

March 19.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

Indian Section.

Thursday afternoons, at 4.30 p.m.:—

February 13.—

March 13.—

April 3.—Brigadier-General Lord Montagu of Beaulieu, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

Colonial Section.

Tuesday afternoons, at 4.30 p.m.:—

February 25.—Edward J. Duveen, Fellow of the Royal Statistical Society, "Key Industries."

March 4.—Professor John Cunningham McLennan, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

MAY 27.—SIR EDWARD R. DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced :—

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

W. NORMAN BOASE, "Flax."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

JOHN A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JANUARY 20...Chadwick Lecture, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m. Mr. A. H. Barker, "Fuel Economy and Health." (Lecture III.)

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Miss C. L. Maynard, "The Influence of Christianity on the Position of Women."

Geographical Society, Kensington Gore, W., 5 p.m. Colonel Winterbotham, "British Survey on the Western Front."

British Architects, Royal Institute of, 9, Conduit-street, W., 5.30 p.m. Mr. M. H. Baillie-Scott, "The Making Habitable of Old Dwellings in Town and Country."

TUESDAY, JANUARY 21...Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Messrs. A. Campbell and W. J. Wilson, "Paraffin Wax and its Manufacture."

Statistical Society, at the Surveyors' Institution, 12, Great George-street, S.W., 5.15 p.m. The Right Hon. Herbert Samuel, "The Taxation of the Various Classes of the People.'

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. A. Wise, "Modern Practice in Office Lighting."

Royal Institution, Albemarle-street, W., 3 p.m. Professor S. Wilkinson, "Lessons of the War." (Lecture II.)

Secretaries' Association, Winchester House, Old Broad-street, E.C., 7.15 p.m. Mr. F. P. Fausset, "Company Law Reform: the Committee's Report."

Faraday Society, at the Chemical Society, Burlington House, W., 5 p.m. Papers and Discussion on "The Theory of Ionisation."

WEDNESDAY, JANUARY 22...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Colonel H. G. Lyons, "Meteorology during and after the War."

Geological Society, Burlington House, W., 8 p.m.

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, 4.30 p.m. His Honour Judge Parry, "Industrial Reconstruction in Government Departments."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5 p.m. Sir Edward Brabrook, "Literature and the State."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor D. I. W. Hall, "Industrial Hygiene in Relation to War Strain and Technical Development."

THURSDAY, JANUARY 23...Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. Norman Collie, "Chemical Studies of Oriental Porcelain." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. W. C. F. Anderson, "Some Balkan Problems."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. A. P. M. Fleming, "Planning a Works Research Organisation."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. M. N. Ridley, "Corrugated Sheeting."

FRIDAY, JANUARY 24...Royal Institution, Albemarle-street, W., 5.30 p.m. Lieut.-Colonel A. Balfour, "One Side of War."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. 1. Principal S. Skinner, "Notes on Lubrication." 2. Professor W. B. Morton, "On Sir Thomas Wrightson's Theory of Hearing." 3. Dr. A. Russell, "Electrical Theories in Connection with Parallel Cylindrical Conductors."

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. 1. Mr. T. T. Heaton, "Electric Welding." 2. Mr. H. Cave, "The Development of the Oxy-acetylene Welding and Cutting Industry in the United States." 3. Mr. J. H. Davies, "Oxy-acetylene Welding." 4. Mr. F. Hazledine, "Oxy-acetylene Welding."

SATURDAY, JANUARY 25...British Psychological Society, King's College, Strand, W.C., 3 p.m. Dr. W. H. R. Rivers, "The Danger Instincts."

Physiological Society, King's College, Strand, W.C., 3.30 p.m. Dr. G. A. Buckmaster, "Proteins other than hæmoglobin as transporters of CO_2."

Royal Institution Albemarle-street, W., 3 p.m. Rev. Canon J. O. Hannay, "The Irish Literary Renaissance." (Lecture II.)

Chromatics, International College of, Caxton Hall, Westminster, S.W., 3 p.m. Rev. J. Sibree, "Stained Glass: Ancient and Modern."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—January 17, 1919.

No. 3453. JANUARY 24, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY
OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,453. VOL. LXVII.

FRIDAY, JANUARY 24, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 29th, at 4.30 p.m. (Ordinary Meeting.) FREDERICK KEEBLE, C.B.E., M.A., Sc.D., F.R.S., Controller of Horticulture, Food Production Department, Board of Agriculture and Fisheries, "Food Production by Intensive Cultivation." LORD LAMBOURNE, C.V.O., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

THE SWINEY PRIZE.

A meeting of the Adjudicators of the Swiney Prize, appointed under the will of the late Dr. George Swiney, was held at 3.30 p.m. on Tuesday, January 21st, 1919, at the house of the Royal Society of Arts. Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, was in the chair.

The Secretary read the advertisement convening the meeting.

The Secretary read a report from the Joint Committee of the Royal Society of Arts and the Royal College of Physicians, recommending that the prize should be awarded to Dr. Charles Arthur Mercier, F.R.C.P., F.R.C.S., for his work "Crime and Criminals." Dr. Mercier received the prize in 1909 for his book, "Criminal Responsibility."

It was thereupon moved by Dr. Norman Moore, President of the Royal College of Physicians, seconded by Sir Henry Trueman Wood, and resolved: "That the Swiney Prize be adjudged to Dr. Charles Arthur Mercier, F.R.C.P., F.R.C.S., for his work, 'Crime and Criminals.'"

SIXTH ORDINARY MEETING.

Wednesday afternoon, January 22nd, 1919; SIR WILLIAM NAPIER SHAW, Sc.D., F.R.S., Meteorological Adviser to the Government, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Alam, Sahebzada Md. Habeeb, Calcutta, India.
Dilke, Pearl, Lady, Brighton.
Edwards, H. J., Elyria, Ohio, U.S.A.
Spicer, A. Dykes, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Armstrong, P. A. E., Watervliet, New York, U.S.A.
Gow, Charles, London.
Hunter, J. A., Halifax.
Janney, Reynold, New York City, U.S.A.
Latham, Thomas Paul, Weybridge.
Matthews, Mortimer, Cincinnati, Ohio, U.S.A.
Mullett, W. C. B., Wexford.
Parsons, Arthur David Clere, B.A., Stocksfield, Northumberland.
Sharwood, James Allen, Worcester Park, Surrey.
Thomas, John Godfrey Parry, Leyland, Lancashire.
Walker, Harold Gibson, Whitby.
Wans, Oswald, Assoc.M.Inst.C.E., M.I.Mech.E., Lincoln.
Weeks, Herbert Thomas, Tunbridge Wells.
Wenger, Albert Francis, Stoke-on-Trent.

A paper on "Meteorology during and after the War" was read by COLONEL H. G. LYONS, D.Sc., F.R.S., Acting Director of the Meteorological Office.

The paper and discussion will be published in the *Journal* of February 7th.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

Wednesday, January 15th, 1919; Sir William M. T. Lawrence, Bt., in the chair.

The paper read was—

ENGLISH CARPETS.

By A. F. Kendrick,
Department of Textiles, Victoria and Albert Museum.

My first task is briefly to state the limitations I shall observe, as well as the latitude I ask you to allow me, in dealing with the subject of English carpets this afternoon. It should be mentioned at once that I shall have very little to say about that great industry of power-loom carpet-weaving which, during the last hundred years, has given world-wide currency to the names of the towns in England and Scotland where the manufacture has been carried on. This reservation must not be traced to any failure of mine duly to recognise the high attainments of that industry nor the skill and enterprise which have marked its wonderful progress. It will be generally agreed that such a subject may fairly claim our attention on another occasion, and if that occasion should arise the task should be entrusted to someone better equipped to deal with it. By restricting our scope more particularly to hand-woven pile carpets, we shall be enabled to spare time for a brief inquiry into the treatment of the floor in the household economy of mediæval England. During the last thousand years or so the term "carpet" has meant a variety of things. In the sense in which it is used to-day, and in any sense cognate to it, carpets were unknown in this country five hundred years ago. In the West, their gradual adoption has kept pace with progressive ideas of comfort. In the East they are the outcome of the conditions of daily life, and they have always been indispensable. There are very few carpets now in the world more than five hundred years old, but that fact provides no clue to the antiquity of the carpet, since such goods were liable by their nature to perish in the using. Whatever our uncertainties may be in regard to the East, we can be pretty sure that practically nothing was known in England of the pile-carpet before the reign of Henry VII. at the earliest, if not that of his successor. There are many illustrations of interiors in English paintings and miniatures executed before those times, but in none of them, so far as have I been able to discover, is a pile-carpet represented. As late as the fifteenth century a flooring of stone or earthenware tiles, or, perhaps, wood-boards, was considered to need no covering for the sake of comfort or appearance. The occupants of the more modest dwellings probably had often to be content with the bare earth; and, indeed, some of our country churches were no better off at a much later time. A "foot-cloth," a piece of rich stuff of some kind, would be laid down before the altar of a church or before the throne in the royal presence-chamber.

These cloths, spread out in special places on occasions of ceremony, were only in a very limited sense the predecessors of the modern carpet. They did not entirely meet the problem of the treatment of the floor in mediæval times. It is true that æsthetic considerations made few demands in the matter, but the question of hygiene was one not to be lost sight of. Those were not squeamish times, but some concession had to be made to the habits of daily life. One would as soon have thought of leaving the floor of a decent house swept and bare as one would think to-day, for example, of dispensing with the sawdust in the bar of a roadside tavern. Thus arose the custom of scattering sweet rushes, hay, straw, foliage, fragrant herbs or flowers over the floor. These could be renewed at will, and the broom might be more or less drastically used, at regular or irregular intervals, according to the taste of the individual. The purpose in view was utility, not ornament. It is perfectly clear that the custom was not merely a concession to the primitive rudeness of country manners. As we shall see in due course, rushes were strewn over the floor of the royal presence-chamber as late as the end of the sixteenth century. Old comments on the fashion of removing and renewing these provisional floor-coverings raise serious doubts as to whether they really served their ostensible purpose at all. The general practice seems to have been to renew the top layer from time to time, while that underneath entirely escaped the broom and remained to pollute the air for years. Even the rushes that were gathered up were thrown into the street, where, in the words of a commentator, they only bred a general plague instead of a particular one. This account sounds like the dark ages, and we might imagine ourselves among the rude dwellings of the Anglo-Saxons. If anyone should doubt its applicability to so late a time as the sixteenth century, he would do well to read what Erasmus has to say on the subject. The great scholar, it is well known, studied at Oxford as a young man, and

he visited this country on more than one occasion subsequently, so that he knew what he was writing about. In a letter to John Francis, physician to Cardinal Wolsey,* he refers to the practice of spreading earth or rushes on the floor, stating that they were so renewed from time to time that an underlayer might remain undisturbed for twenty years, becoming charged with beer, remnants of food, and filth indescribable. No wonder that he thought the odour given forth far from salubrious to the human frame, and that he expresses the opinion that the island would be much healthier if the use of rushes were given up.

But the time had not yet come for the general acceptance of that doctrine. In France the loose rushes had long before given way, in princely houses at any rate, to rush matting, the mere use of which would impose a certain restraint on domestic habits. In the famous manuscript "Book of Hours," of the early years of the fifteenth century in the Château at Chantilly, a picture represents the Duc de Berri seated at dinner. The floor of the chamber is covered with rush-matting. We shall not find the same thing in England for more than a century.

Here is a page from a celebrated manuscript in the Library of Lambeth Palace. The work is entitled, "Dictes and Sayings of the Philosophers," a Latin book translated into English by Earl Rivers. In this illustration the translator is seen offering the book to King Edward IV., who is accompanied by his queen and his son, afterwards King Edward V. It will be noticed that the cloth of honour is brought forward so as to pass under the feet of the king, while loose rushes, painted bright green in the picture, cover the whole of the rest of the floor. After seeing this painting it is not surprising to read Sir Thomas More's account of the unfortunate queen there represented, when in the sanctuary at Westminster, sitting alone amongst the rushes in her grief and distress.

Even after another century had passed, at the end of Elizabeth's reign, the state of affairs was very much the same. Paul Hentzner, a German who came to London in 1598, states that Queen Elizabeth's presence-chamber at Greenwich was strewn with hay. In fact, the interior economy of our houses seems to have been in harmony with their outward appearance. We recall the picturesque exclamation of the Spaniard in Queen Mary's time: "These English have their houses made of sticks and dirt, but," he is careful to add, "they fare commonly as well as the king."

* Allen, "Selections from Erasmus," p. 126.

We seem to feel a welcome breath of fresh air when we read that Wolsey caused the rushes at Hampton Court to be changed every day. In this he was in advance of his times, for his contemporaries made of this circumstance a text for diatribes against his extravagance.

This was not Wolsey's only innovation, as we shall see in due course; but first we must consider the gradual change from the loose rushes to rush-matting. This appears, on the face of it, to be no very great step forward, but as an indication of the growing sense of the amenities of life it is not without significance. It shows that the rude and casual habits, which we should now associate with a stable or outhouse, were gradually giving place to ways more in keeping with our present ideas.

Rush-matting, although used to cover the floor by our nearest neighbours, the French, at the beginning of the fifteenth century, does not appear to have been adopted in England before Henry VIII.'s reign, and its general use cannot be ascribed to an earlier time than that of James I. Ignorance of such a simple expedient need not be thought of; rather one is led to believe that the habits of daily life did not yet permit of the change. The earliest representation of rush-matting in an English picture to which I can refer you is in a portrait of Henry VIII. at Belvoir Castle.* The rushes are simply plaited in a diagonal fashion. We shall want the evidence of this picture again in a few moments, when we come to the use of pile-carpets. But first let us examine another painting, a miniature of Sir Christopher Hatton, Lord Keeper under Queen Elizabeth, who died in 1591. We are on firmer ground here, since the miniature is the work of an English artist, Nicholas Hilliard, who seems to represent Sir Christopher as he might be seen at home by his contemporaries. This miniature is in the Salting Collection at South Kensington. The portrait of Henry VIII. is rather a ceremonial picture, and having been painted by Holbein details may have been introduced not strictly in keeping with English life at the time. Another early example of rush-matting may just be referred to in passing—in a portrait of the Earl of Pembroke (died 1570) at Wilton House.

We have now reached the point where the pile-carpet first comes on the scene. This,

* The Drapers' Hall is said to have had mats in the Chequer Chamber, and rushes in the hall, in 1495, but we have no information as to the material of the mats.

again, seems a matter of small significance in itself, but perhaps it implies a great step in the progress of household economy in the country. Cardinal Wolsey was probably the first Englishman, for a subject at any rate, to bring pile-carpets into use. They had long been known, though only as rare and valuable commodities, on the Continent. A minister who, if rumour spoke truly, fed his aspiring soul with dreams of the papal tiara, and who at one time would have rejoiced to secure the imperial crown for Henry, must not be chargeable with insular habits. He must be equipped in the fashion of the times, and carpets must be got. The foreign trade of the country being then largely in the hands of Continental merchants resident in London and the seaports, he could apply to the Venetian factors; but that course would be tedious and slow. The steps he did take lifted the question out of the sphere of commerce into that of international diplomacy. The despatches and reports of Sebastian Giustinian, then Venetian Ambassador in England, show how much significance that dignitary attached to a request from the Cardinal for some carpets.* Negotiations went on for more than a year. In June, 1518, Giustinian writes home to the Signory from Lambeth that the Cardinal had promised to take him before the Council and obtain audience for his arguments in regard to the repeal of the duties on Candian wines imported into England by the Venetian traders. After these colloquies, the ambassador proceeds: "his right reverend lordship requested me very earnestly to contrive with the magnifico the captain and the masters that, paying for the same, he might have certain choice carpets and some other articles, but above all the carpets. I told him that I did not know whether there were any, but that if there were, his lordship should have them. I suspect he will not be accommodated, which will prove of serious detriment to us; whereas had he received twelve or fifteen small handsome carpets, he would have been extremely satisfied. Should your Excellency think fit, you might see either to forwarding them by land, or promise that he should receive some by the next galleys." In November of the same year the ambassador writes again from Lambeth. The Cardinal, he says, was extremely angry with the Venetian merchants in London, who appear to have done something which led him to believe that they thought too lightly of his authority in the kingdom. Giustinian had been to see him with the object of arranging the dispute. He appears to have been in some degree successful. The Cardinal sent for the merchants, who offered him seven very handsome Damascene carpets. He was willing to accept this present from the ambassador, but not from the merchants. In the end, he agreed to regard them as the joint gift of both. These carpets were but a drop in the ocean. The autumn of the next year came, and still the request for the carpets, and the contingent question of the duty on the Cretan wines, remained as before. Giustinian is by this time back in Venice. In October 1519, he makes a report in the Senate on his legation in England. The Cardinal is still very anxious, he says, for the Signory to send him one hundred Damascene carpets, for which he has asked several times. The Senate is urged to make the gift, and even if the Signory does not choose to incur the expense, the London factory will take it on themselves. The gift might easily settle the affair of the wines of Candia, whereas it would be idle to discuss that matter further until the Cardinal receives his hundred carpets. Wolsey received some carpets from Venice, but whether his demand for a hundred was fully satisfied we cannot say. It is equally uncertain what became of those he did receive. None of them are at Hampton Court. Perhaps some of the carpets appearing in the portraits we now have to consider may have been among those obtained by Wolsey. Even if that should not be the case they were, beyond doubt, of the same kind.

The first picture we have to examine is the full-length portrait of Henry VIII. at Belvoir Castle, to which reference has already been made. The king stands on a carpet with a pattern of arabesques in large compartments. A royal portrait-group, painted by Holbein, in the Privy Chamber at Whitehall, after that palace had been handed over to the king by Wolsey, perished in the fire of 1697–8, but copies made before that date show the king standing on a carpet somewhat similar to that at Belvoir.* Still another portrait of Henry, in Earl Spencer's collection at Althorp, claims our attention. The king is seated at a table with the Princess Elizabeth, the jester Somers stands behind them. On the table is spread a small Oriental rug. It will be remembered, of course, that for a long time after Oriental carpets were first brought into Europe it was

* "Four Years at the Court of Henry VIII. Selection of despatches, etc." Vol. II. pp. 198, foll.

* There is a copy by Remigius van Leemput at Hampton Court.

far more common to use them as table-cloths than as floor-coverings. Evidence on this point meets us continually in Flemish, Dutch, and Italian pictures of the fifteenth to the seventeenth century. They were not made to withstand indefinitely the rough usage that spreading on the floor entails, and to subject a fine old Oriental carpet to such treatment is a great mistake.

It cannot be claimed that any of the carpets brought into England in the time of Henry VIII. have lasted to the present. There were never very many of them, and their chances of surviving would be correspondingly small. In those days we were outside the main arteries of commercial traffic between Asia and Europe. Our merchant adventurers had not yet penetrated the Mediterranean or the White Sea in any organised fashion. Venice then held the position taken afterwards by Amsterdam and London when the Cape route to the East had been developed. Carpets were carried into Italy in large numbers, and many are still in that country. They agree very closely with the types illustrated in the three portraits we have just been considering, and there is no difficulty in identifying them as the work of Anatolian weavers in the hill-country behind Smyrna. Here is a carpet which was probably in Italy from the time when it was new in the sixteenth century until it was acquired in Florence, a few years ago, for the Victoria and Albert Museum. You will see that it corresponds very closely with that represented on the table in the picture at Althorp. It is a relic of the export trade in carpets from Smyrna, which began a century earlier, and has probably gone on without effectual interruption ever since. It remains now to be seen whether the great war has killed it.

The actual making of pile-carpets in this country followed hard upon their first importation from the East. This is a notable fact. Although we were handicapped by our tardiness in the adoption of the pile-carpet, in the actual making we had almost the position of pioneers in Europe.* Text-books usually trace the first attempts in the West to the craftsmen who claimed to be the originators of a process of carpet-knotting in Paris in the early years of the seventeenth century. But here is an English example, bearing a date well back in the sixteenth century. It has in the middle the royal arms of England, with the initials of Queen Elizabeth and the date 1570. On the left are the arms of the borough of Ipswich, and on the right those of the family of Harbottle. The English heraldry is no criterion of the nationality of the weaver, as we shall presently see; but the whole of the rest of the pattern is thoroughly English as well, and typical of Elizabethan times. In particular, the borders of honeysuckle and oak-stems are to be noticed. Of course, it might be argued that it would be as easy to send out to the East designs for the whole as for the heraldry only, but all evidence tends to show that this was not done. The Anatolian weaver would not work freely and successfully under such restraint. The case might have been different had the craftsmen belonged to the Far East. The carpet is the property of Lord Verulam. It is probably the oldest existing example of carpet-knotting in England. Attempts at carpet-weaving may have been made at an earlier date, even under Wolsey himself; for among his household goods at Hampton Court were several woollen "table-carpets of English making." The patterns of these are described, and they are not inconsistent with the idea that the carpets may have been of knotted work; but, still, we cannot be sure. It may be taken for granted that, in view of the wide disparity as regards the cost of labour, the English craftsman in the days of Elizabeth was no better able to enter the lists against the skilled Oriental weaver than he is to-day. But for all that, the English worker had his own sphere, and the craft, once taken up, was long kept alive.

Before the end of Elizabeth's reign, the English Turkey (or Levant) Company had begun direct trading with the Eastern Mediterranean, and carpets were more easily obtained. It was a favourite practice to send out drawings of the customer's shield of arms to be woven into the fabric. We will examine two examples before we proceed to consider some other specimens woven in England.

The first is one of a set of three in the possession of the Duke of Buccleuch. The pattern is very similar to that in the picture of Henry VIII. at Althorp. The arms in the middle of each border are those of Sir Edward Montagu (died 1602), ancestor of the present owner of the carpet. The date 1585 may be seen woven into the outer edge. The two others are of the same design with the same arms, and as one of them is dated 1584, the order seems to have taken

* The case of Spain is hardly an exception. Carpets were made there as far back as the fifteenth century, but the craft was introduced and maintained by immigrant weavers.

some time to execute. This type of pattern is generally ascribed to the weavers of Ushak, long famous as a carpet-weaving centre, which lies in the Anatolian hills not far from Smyrna. The latter place was for more than two centuries the chief depot of the Turkey Company in the East, and there can be little doubt that Sir Edward Montagu had these carpets made through the agency of that company. The other carpet is in the Victoria and Albert Museum. It has a stiff geometrical pattern. The shield of arms in the middle of three of the borders is that of Sir Edward Apsley. An unusual feature is the inscription, along one of the short sides, in beautiful Elizabethan characters in knotted pile, like the rest of the carpet. It reads as follows: "Feare God and keepe his commandements made in the yeare 1603." The knighthood was conferred in that year, and the carpet may have been made to commemorate the event. The design is Eastern, but the inscription is rendered with so much spirit that one feels almost bound to admit the possibility of an English origin for this carpet. The balance of probability is, however, strongly in favour of the East.

There can be no doubt about the next example, a panel bearing the arms of Queen Elizabeth, with her initials and the date 1600. This remarkably fine specimen is in the Victoria and Albert Museum. The design is typical throughout of the English art of the time. It is not a large piece, and it could hardly have been intended for the floor. This knotting process came to have the name of "Turkey work" in England. The knot is quite a simple one—the same as that generally used in Turkish carpets. Panels made in this way were often used for upholstery. For example, there were "Turkey-work" chairs, as well as carpets at Ham House in the seventeenth century.* Here is a chair in the Victoria and Albert Museum, with panels of knotted work on the seat and back, the latter dated 1649. The upholstery appears to be the original covering. A separate panel, also in the Museum, with a pattern of birds and flowers, has evidently been used for a similar purpose.

The Cathedral of Norwich possesses some seventeenth century cushions of this work, with the arms of the city upon them.

The carpet we have now to examine is a very fine example of the time of James I. The date 1614 will be found in the border, and the whole design is characteristically English of the period. The carpet belongs to Sir Hamilton Hulse. There is an English carpet of similar design at Knole. A second example at Knole has the arms of the Countess of Dorset, who died in 1645.

It may have been noticed that Persia, the country *par excellence* of carpet-weaving, so far has not come into our history. The fact appears to be that Persian carpets were not seen in Western Europe before the seventeenth century, although their fame had spread as far as to England. Hundreds of carpets are illustrated in the fifteenth and sixteenth century paintings of Italy, Spain, Germany, and the Netherlands, but not one of them is Persian. At one time it seemed as though trading relations with that country might be developed through Russia. The Merchant Adventurers who obtained the charter for the Russia (or Muscovy) Company in 1554 got into contact with Persia. But their principal trade route was by way of the White Sea, and from that quarter transport difficulties, especially for such bulky goods as carpets, were more than usually serious. English travellers, however, got to Persia early in Elizabeth's reign, and a little later an effort was made to find a Persian carpet-weaver who might be induced to come to England.

A chapter in Hakluyt's "Voyages" is entitled "Certaine directions given . . . to M. Morgan Hubblethorne, Dier, sent into Persia, 1579." In this chapter we read as follows: "In Persia you shall finde carpets of coarse thrummed wool, the best of the world, and excellently coloured: those cities and towns you must repair to, and you must use means to learn all the order of the dyeing of those thrums, which are so dyed as neither rain, wine, nor yet vinegar can stain. . . . If before you return you could procure a singular good workman in the art of Turkish carpet-making, you should bring the art into this realm, and also thereby increase work to your Company."

It will be seen that Hakluyt has no qualms about calling the Persian workman a maker of Turkish carpets. That term was used to designate any carpet made by the knotting process, just as an "Axminster" or "Brussels" carpet might be made anywhere nowadays.*

We have no evidence that Hubblethorne

* In the Inventory of 1679 there were mentioned four Turkey-work carpets in the Wardrobe, and twelve Turkey-work chairs and one Turkey-work carpet in the lower offices. Mrs. Charles Roundell, "Ham House," pp. 50, 51.)

* The Girdlers' carpet, made at Lahore, was called a Turkey carpet. Such expressions are partly to be explained by the vague geographical sense of our forefathers. Goods brought over by the East India Company were often described as Indian, Chinese, or Japanese indiscriminately.

secured his Persian workman. Carpet-knotting in the old style went on, however, until the middle of the seventeenth century. By that time the country was richer, and the trade of the East India Company having developed; there was no real difficulty about getting carpets from India and Persia, though it was a costly business. The Girdlers' carpet, it is well known, was obtained through the East India merchants in 1634. It was made at Lahore, in the factory established with Persian workmen under the Mogul emperor Akhbar. The quantity of carpets of this Indo-Persian class still be to seen in old English houses bears witness to the extent of this commerce, and, incidentally, to the national wealth in the latter half of the seventeenth century. As a consequence, the industry at home seems practically to have died out; and when, as we shall see in a moment, it was revived in the middle of the eighteenth century, it was regarded as a new industry.

Meanwhile, experiments in carpet-knotting "after the manner of Turkey and the Levant" had been made in France, and these should be briefly referred to, as they are relevant to our subject. Jean Fortier, in 1601, and Pierre Dupont, who followed four years later, claimed to be originators of the process. Dupont was given a workshop in the Louvre; and in 1626 a pupil of his founded the Savonnerie factory in a suburb of Paris. It is no part of my task to trace the uninterrupted career of the great French factory, but although our neighbours were later than ourselves to enter the field, the first attempt to reawaken the industry in England owed its inception to their operations.

It came about in this way. Two craftsmen in the Savonnerie at Chaillot, having some difference with the administration, removed to London in 1750, and began making a carpet in a room at Westminster. They had raised some money by subscription, but they soon got into difficulties. In the end they applied to a fellow-countryman in London, Pierre Parisot, a tapestry-weaver. Parisot succeeded in interesting the Duke of Cumberland, and engaged the men in 1751. The factory was removed to Paddington, and the first carpet made was presented by the Duke to the Princess of Wales. After two years the works were removed to Parisot's tapestry-factory at Fulham. Great expectations were raised by the undertaking, but its career was short. The entire works of the Fulham factory were sold by auction in London in 1755. It is the usual story of such enterprises in England. The work was costly, and there was only a limited demand. Perhaps had the factory been able to pull through the first few years of effort and financial straits, its career might have been assured, but even that is doubtful.*

The models and appliances thus fell into other hands, and so the failure of Parisot's venture must have helped towards the success which attended other efforts made about that time. It is a pleasant task to recall to the memory of this audience that the Society under whose auspices I am privileged to give this paper contributed materially towards the same end. By its financial help, and still more by the encouragement which that implied, a career of prosperity began, and one factory still prospering to-day traces its origin to a recipient of the Society's awards.

It was in 1756, the year following the sale of the Fulham works, that the Society of Arts first offered a premium for making carpets in England in imitation of those made in Turkey and Persia. The name of Thomas Moore, of Chiswell Street, Moorfields, is the first on the list of recipients. A carpet he produced to the Society was considered to be "in many respects equal, and in some respects superior, to those imported from Persia and Turkey."† He received a premium of £25 in 1757, and a like sum was awarded to Thomas Whitty, of Axminster. The next year Whitty received £25 again; while Passavant, of Exeter, received an equal amount. Again, the following year (1759) the Society made an award of £50, giving £30 to Whitty and £20 to William Jeffer, of Frome.

More than twenty years later the good results of these awards were apparent. There is a note in the first volume of the Society's *Transactions* (1783) that by them the manufacture of carpets "is now established in different parts of the kingdom, and brought to a degree of elegance and beauty which the Turkey carpets never attained." That expression of opinion is coloured by the tastes of the day, which would have discovered more beauty in the Græco-Roman elegancies of the brothers Adam than in anything the East ever had, or ever could, produce. But we are in a position to judge for ourselves.

Not much appears to be known of the subsequent career of Jeffer's factory. In regard to Passavant's at Exeter, Sir Henry Trueman Wood, in his history of the Society, points out that it seems probable that it was the one founded

---

* See the *Gentleman's Magazine*, Vol. XXIV. 1754, p. 385.

† "A Concise Account of the Rise . . . of the Society. . . . By a Member of the said Society." 1763. p. 58.

about three years earlier, and mentioned by Johnson's friend Baretti two years later.

The other two recipients, Moore and Whitty, attained a greater celebrity. Moore seems to have attracted the favourable notice of Robert Adam, and this brought him commissions for carpets for mansions built or enlarged by that celebrated architect. The carpet now represented on the screen is in the red drawing-room of Syon House. The design is in the style which we have learned to associate particularly with the brothers Adam. There can be no doubt as to the craftsman responsible for the weaving. His name, "Thomas Moore," with the date 1769, is woven into the border. At Osterley, another house associated very extensively with Robert Adam's activities, the Earl of Jersey possesses several carpets which are shown by the records to have been made by Moore. The designs for four of these are in the Soane Museum. Those for the Tapestry Room and Etruscan Room are dated 1775; that for the State bedroom is dated 1778. There is no date on the design for the drawing-room. The Soane Museum has an extensive collection of Robert Adam's designs for carpets.

Thomas Whitty's name appears three times in the list of the Society's awards. His factory outlasted the others. The industry which still flourishes at Wilton traces it origin to him. He first started carpet-making at Axminster, in the Court House near the church, in 1755. There carpets continued to be made for about eighty years. That factory was succeeded by Moody's, at Wilton, where carpet-making has gone on ever since.

Among the Axminster products were some very elaborate and costly carpets made for the Pavilion at Brighton. The expenditure on the building and equipment of this royal residence was very lavish, and the carpets were in keeping with the general scale of magnificence. The subject now on the screen represents part of an enormous carpet made for the Saloon, about 1823. It was shaped at the ends to fit the room. The portion now preserved represents the two ends sewn together, with pieces inserted to make it rectilinear. In its original state it is described as "very superb and manufactured at Axminster from Mr. Jones' design." It cost £620. The pattern is on a light ground, and shows the influence of the Chinese taste so conspicuous in the decoration of the Pavilion.

In another carpet, made for the Music Room, the pseudo-Chinese style is still more marked. It is now only a fragment, but an account is given by Nash and Brayley,* who describe it as "one of the largest in the kingdom, its dimensions being 61 ft. by 40 ft., and its weight about 1,700 lb."† It was made at Axminster to fit the room, costing £700.

These two carpets from the Pavilion are now at Buckingham Palace.‡ Another carpet preserved there, and now shown on the screen, was made for the Throne Room at Carlton House. It is of earlier date than the Pavilion carpets, having been woven about the year 1790; the carpet must be English, but we cannot be certain who made it. The influence of the Pompeian style, much in vogue at the time, is very plainly to be seen.

Tradition is probably reliable in ascribing the carpet now shown to the weavers of Axminster. It was made for a former rector of the place, and was given by his grandson, Mr. H. G. M. Conybeare, to the Victoria and Albert Museum. The pattern of large flowers is in colours on a dark-green ground.

We are fortunately in possession of some information concerning the history of the carpets of the eighteenth and early nineteenth century that we have just been examining. There are, of course, many other hand-knotted carpets in the country about which we do not know so much. We shall not have time to consider many of these this afternoon, but I have selected two for examination, as they exhibit features not met with in the carpets so far illustrated. The first is one of several of the same period in the possession of Sir Francis Burdett at Ramsbury Manor. The free treatment of the flowers on the red-figured ground is very effective. The style of the design suggests a French model of the period of Louis XV., but there is a certain waywardness about it, if I may put it that way, which seems to belong rather to English art. Personally, I am very much inclined to regard it as of English make, and as Ramsbury is not very far from Axminster, I consulted Mr. Gow, of the Wilton works. He does not, however, recognise it as Axminster work, and suggests a French origin. Perhaps some evidence may be forthcoming in the future to settle the question.

An equal uncertainty exists about another carpet, not much later in origin but very different in style, which we are now to examine.

* "Illustrations of Her Majesty's Palace at Brighton," 1838, p. 9.

† This is completely outclassed by a carpet lately made in Donegal, weighing 2¼ tons.

‡ Another carpet, for the Banqueting Room, was made at Axminster to Mr. Jones' design, costing £735.

It is one of several at Devonshire House. The free rococo design of the Ramsbury carpet contrasts with the stiff classicalism and geometrical spacing of this pattern. It is obvious that we have here to do with what is universally known as the "Empire" style. This pseudo-Roman style had its full development in France at that time of splendour ushered in by the assumption of the Imperial crown by Napoleon. There was a great revival of artistic activity following that event, and the looms of the Gobelins and the Savonnerie became busy once more. Many carpets were made for Napoleon resembling this example from Devonshire House in style, though their design was more elaborate as a rule. The style soon gained a vogue outside France, and until further information is obtained we may still recognise the probability that this carpet may have been made in England.

An account of the carpet-knotting industry in this country would lack its natural counterpart if all reference were omitted to the weaving of carpets in Scotland and Ireland. The manufacture of carpets in the south-west of Scotland was carried on with much success in the second half of the eighteenth century. The industry has had an unbroken and prosperous career ever since. It seems likely that hand-knotting was not adopted there at first, but in 1831 the Trustees for Manufacture in Scotland awarded two premiums—of £150 and £30—for four Turkey carpets to a Kilmarnock firm. These are said to have been the first of that luxurious and costly type manufactured in Scotland.* Hand-knotted carpets continued to be made in the south-west of Scotland for about twenty years. Early in the present century efforts were made to start carpet-knotting among the fisher-folk of Sutherland and Caithness, but in the end it was found impossible to induce the girls to settle down to regular work. The looms were removed to Glasgow, where they were kept going until the outbreak of the war. There are still deft fingers ready to make carpets to-day, whether knotted after the Turkish or the Persian manner. But the mainstay of the carpet industry of Scotland has ever been the use of those ingenious contrivances for producing a pile-surface by mechanical means.

When we come to Ireland, we must begin a little farther back. Irish "rugs" were in demand in this country in the sixteenth and seventeenth centuries. But the "rug" of those days was a rough material, shaggy in appearance, perhaps like a modern blanket. Holinshed has a story of a man who went to a bear-baiting in London on a frosty morning wearing a Waterford rug. "The mastiffs," says the Elizabethan chronicler, "had no sooner espied him than they set on him, thinking him to be a bear." It is a long stride from the Waterford rug of Queen Elizabeth's days to the Donegal carpets of our own times. Perhaps the chief link connecting them is the quality of the Irish wool. The hand-knotted carpet industry was introduced, or revived, in Ireland about twenty years ago. A factory was opened at Killybegs in 1898, and the work was soon extended to other centres in North and South Donegal. Before long, hundreds of workers were employed. Some very good results have been obtained. An imposing product of the Donegal factories is in the Library of Australia House in London. It measures 46 ft. 6 in. by 23 ft. The general tone of the ground is brown. There is a fine border of wattle and vine-leaves. This carpet is matched by others of the same manufacture now in this country. Others are also to be found in Scotland and Ireland and on the Continent, as well as in Canada, the United States, Egypt and South Africa. Fine carpets have also been made in Kildare and in Queen's County.

Before passing to a few concluding remarks about the future prospects of the carpet-knotting industry, the carpets made by our great craftsman William Morris must occupy our attention a few moments. It was in 1879 that his first experiments in carpet-knotting were made in Queen Square. Then carpet looms were set up at Hammersmith, and finally the work was transferred to Merton. Morris, of all men, knew the right use of museums. A careful study of the old productions of the East was the foundation of his work. "They show us the way to set about designing such things," he said. Modern carpets, "while they should equal the Eastern ones in material and durability, should by no means imitate them in design, but show themselves obviously to be the outcome of modern and Western ideas." This aphorism might be put up over the doors of our carpet factories to-day.

Morris made some noble carpets. The large carpet made for the Earl of Carlisle's drawing-room at Naworth, was finished in 1881. It took nearly a year to make, and "weighed about a

* British Association Reports, Glasgow, September, 1876. "The Textile Industries," by James Paton, pp. 204-206.

ton." Another fine carpet was made for the late Earl of Portsmouth. It was arc-shaped, made so as to fit the place for which it was destined at Hurstbourne. The floral pattern is interrupted by three large shields bearing the arms of the Earl and the Countess. Part of the original design is now shown on the screen.

Another carpet made by Morris is here represented. Its design exemplifies the principles he laid down. We see the influence of Persian ornament, but yet the whole has a Western character.*

It must be admitted, not without reluctance, that the future lies with the power-loom. But it would be a thousand pities if hand-knotting were to die out, either in the East or the West. For a good many years the Western market in Oriental carpets has drawn largely upon the reserves in the East. But those reserves are now practically exhausted, and the exportation can only keep pace with contemporary production. That has been severely checked by the war, and the return to peace will not bring back old conditions. Some of the best fighting material of the Turks was recruited from the Anatolian highlands, the chief seat of the carpet industry. The extension of the war-zone to Persia has had its natural effect on the craft there, and profitable markets have been found for the wool which was formerly used for carpet-making. The wages of skilled carpet-weavers were probably not 10 per cent. of what they would be in England; this state of affairs belongs to the past alone. China has of late years been coming into the market, but the carpets made there are inferior in quality to those of the Nearer East. Under stable government, India seems now to have a chance such as she has never had before, and no efforts should be spared to encourage there the weaving of the best carpets that can be produced. This need not offer any check to the work at home. The industry will not be a large one, but it has its own special field. That has been marked out in some degree by the British productions we have been examining this afternoon. The designs should be on Western lines, so as not to engage in an unequal competition with the East. They may be specially made to suit the shape, the surroundings and the conditions of lighting of rooms, which can in many cases be inspected before the work is begun.

* The carpet by William Morris, shown at the meeting, has now been purchased and presented to the Victoria and Albert Museum by Mr. Thomas Glass, who was present.

To design in monochrome and in monotonous schemes of colour is to sacrifice obvious advantages of the technique, and that should be avoided, except of course in special circumstances. The craft is wonderfully free in its method, and the convenience of mechanical repetition in power-loom work is almost entirely eliminated by the hand-knotting process. Each single carpet may have its own design, with central ornament, corner-patterns, borders, heraldry, personal devices, inscriptions, or anything else suitable.

In addition to carpets, a demand for small decorative panels for upholstery and other purposes could be created. Cannot some of our disabled soldiers be trained for such work?

DISCUSSION.

The Chairman (Sir William M. T. Lawrence, Bt.) said that he had rarely listened to a more arresting paper or one that had kept his attention so closely riveted. Everyone present must be very grateful to Mr. Kendrick for the way in which he had developed a subject that came so closely within the purview of the Society of Arts, Manufactures and Commerce. The author had told him that he thought the work of hand-knotting carpets was particularly suitable employment for the disabled sailors and soldiers, of whom there were unfortunately so many in this country at the present time, and personally he fully agreed with that. Probably many of those present had been to the hospitals and had seen soldiers and sailors sitting up in bed and doing needlework or *appliqué* work, and doing it extraordinarily well. Men could do needlework very well, and the hand-knotting of carpets might be called a form of needlework. Some forms of needlework men could do even better than women, because their hands were larger and had more strength in them, and consequently their work became more even and regular. He therefore thought that disabled soldiers and sailors would do exceedingly good work in the knotting of carpets, because they would be able to pull the knots tightly and regularly. Institutions, Government offices and private firms did not think enough about their carpets. They built their rooms and decorated them, and then they chose their carpets from amongst a number of others and very often chose one that had quite a wrong light on it, *e.g.* a top light instead of a side light. He agreed with the author that people should be persuaded to order their carpets to be designed in harmony with the rest of the decoration of their rooms. It was quite true that such carpets were expensive, but it must be remembered that they would last for a very long time. The carpet in a room should be regarded as the background to the furniture in the same way as the decoration of the wall was the background of the pictures hung upon it, and perhaps the most important feature of the carpet was the border,

because the border framed the furniture in the room in the same way as a picture-frame framed a picture. In Oriental carpets the borders were exceedingly beautiful. He once had a rather unfortunate experience with a little rug that was described to him as an Axminster rug. He bought it for his children, because the pattern on it represented a very lively farmyard, with pigs and hens and so on. When he got it home, he was told it was rather dirty and that it had better go to the cleaners to be cleaned. On arriving home one day about three weeks afterwards, he was met with a smell of benzol, and he saw a dejected looking man standing in the hall with a piece of canvas under his arm. The man explained that he came from the firm of cleaners to whom the carpet had been sent, and, producing the piece of canvas, said: "There is your carpet. As soon as we put it in the benzol in the cleaning-bath the whole of the pattern floated off." That was a form of carpet-making that perhaps the author was not aware of. It was obvious that the little piles of wool had been stuck on to the carpet some time in the forties or fifties by some ingenious maker, and as soon as the carpet was placed into the solvent the whole of the pattern floated off.

Mr. G. P. Baker said that in the research work he was carrying out at the present time he had come across some particulars which might be of interest to the author, although the paper that had been read that afternoon was, he thought, the concentrated essence of research work, and very little could be added to it. Apropos of Cardinal Wolsey and his sixty rugs, he might mention that, in going through Venetian records recently, he had come across a reference to those sixty rugs as having arrived in this country in the year 1520. There was a letter from the Venetian Ambassador in London, Antonio Sivian, to the Signory, stating that he dined with Cardinal Wolsey and some others, and that the Cardinal spoke in terms of great honour of the Signory, and after dinner lavished many praises on the State, adding that he wished to receive the sixty Damascene carpets promised by Sebastian Giustinian. The letter stated that it would be well to make a present to that "individual," who might be styled the King of England, and that the King of France had sent him a golden chalice with a jewelled paten of gold. A few months later the Council decided, in secret session, that it was "expedient at the present time to keep the Right Reverend Cardinal of York well disposed towards us by reason of the supreme authority and favour enjoyed by him with the King of England." "His Right Reverend Lordship having asked the nobleman, Sebastian Giustinian, Knight, for from sixty to one hundred carpets, and having again with extreme earnestness repeated his demand and urged it to our own Ambassador now resident in England," the resolution "To purchase in this our city sixty beautiful and choice carpets at the cost of 600 ducats, the carpets to be selected and purchased as the College shall decree, and sent to London by land and presented by our Ambassador to the Cardinal in the Signory's name" was put to the ballot and carried by 151 ayes to 10 noes, with one neutral. Mr. Baker discovered in subsequent letters that in order to comply with those good intentions, the Council of the College decided to sell the chain given by the King of England to the Ambassador, Giustinian, worth 500 ducats, and also the two cups given by the King of Hungary to the Ambassador Bon, worth about 200 ducats, the proceeds to be expended in the purchase of sixty Damascene carpets to be sent as a gift to Cardinal Wolsey in England. Even that, however, did not pay for the cost of the sixty rugs, because he discovered that later they had to pawn the surplus of the Rhenish Guilders belonging to the Signory as a security for the balance of the sum needed to complete the purchase of the sixty rugs. In October of the same year, 1520, "there arrived from Antwerp the sixty carpets destined as a present for Cardinal Wolsey. . . These were accepted graciously, and the Cardinal inspected them one by one. They were very beautiful, and pleased him much; and he saw the present was worthy of a much greater personage than himself. Thanking the Signory vastly, making many offers of services," he said he "would do everything and anything" in the future. It was now forty years since the speaker made his first journey to Persia, then on pleasure bent, but it afterwards led him to enter the Oriental carpet industry, and thus on such a paper as that given by Mr. Kendrick, he could only think and speak from an Eastern point of view; at the same time, in these days of "repeating machinery," there was likely to be so much sameness in the output that people would tire of such things, and would ask for something made by human hands. He therefore thought there would be great opportunities for craftsmen in the future in the production of hand-knotted carpets. Very little was known about the condition of Persia at the present time. In the north-west of the country, the great carpet centre, the population had been largely depleted by famine and pestilence, and from letters he received dated July he learned that in the regions round Hamadan from 20,000 to 30,000 of the inhabitants had gone and the villages were empty. The British Government had sent out large sums of money for the purposes of relief work. The Armenians had also suffered greatly through the war. They were carpet-knotters, as were all the Christians of Asia Minor, and they were amongst the best knotters in the industry. Nothing official was known at the present time about Asia Minor.

On the proposition of the Chairman, a hearty vote of thanks was accorded to Mr. Kendrick for his interesting paper.

Mr. A. F. Kendrick, in reply, said he was afraid the length of his paper had been the cause of the short discussion that had followed it, and he sincerely hoped that another opportunity would be provided for remarks to be made on the subject. Perhaps anyone who had any remarks to offer on the subject would hand them to the Secretary in writing, so that they could be published in the *Journal*. It was important that those who were interested and experienced in the subject should give their views on it, because the opinions of such persons were of great value. The people of this country were not given to talking, but the time had come when those who could speak with authority on any subject would have to put forward their views upon it, for there would be a great deal of industrial competition to be faced in the future.

The meeting then terminated.

Mr. Arthur Wilcock writes:—After listening to Mr. Kendrick's very interesting and historically instructive paper to-day, I felt it somewhat ungracious to come away without some slight contribution to a discussion of the subject. I know from my own experience how helpful it is to provoke the opinion of those who are interested, and who can approach the subject from other view points. My view point is, naturally, the designer's, and I can see no reason why we in this country should not produce something in carpets quite distinct and national as a contribution to the world's art industry. The examples shown us of the Elizabethan period partook of this distinctiveness. One particularly interesting specimen, dated 1614, a design composed of roses, honeysuckle, and borage, etc., in the filling, and with a border of entirely abstract conventional ornament, is an excellent example as a tradition for the designer to work upon. The reason why of all carpets the Persian and Oriental are so eminently satisfactory as floor coverings is the fact that the craftsman is more often the designer, and he contents himself with nothing more than abstract conventional forms, and well distributed, beautiful colour, perfectly fitted to loom production. To attempt more than this, and bring into a carpet styles of ornament such as in the Adam specimens shown, appears to me quite wrong and unsuited for a fabric built up of a mosaic of wool. I venture to suggest that an Adam room is a far better Adam room with a Persian or Turkey carpet than an attempt to bring down the ornament used on the ceiling to do service on the floor. There is a fitness and appropriateness in all things, and the most fit and appropriate piece of furniture in the average room is a carpet which is designed on an Oriental planning. I can, however, imagine a fresh interpretation of the Oriental method. This William Morris did uncommonly well. Let us therefore saturate our students in the Oriental traditions. Make them think in carpets, and let them loose among the hedgerows and gardens of England. Then bring them back to the studio, and see if the results will not establish a definite style worth setting up in our museums when our day is done. Might it not be an experiment worth making to cultivate a more intimate relationship—or an interchange—with the carpet craftsmen of India, and so graft their tradition on to ours? Another thing that will help towards a distinctive quality will be when our dye chemists, now in full quest, have discovered such colours as will materially influence the artistic character of our productions. Working on these lines, I hope Mr. Kendrick will not think me too much of a visionary when I say I look to the time when English or Anglo-Indian carpets will be as much valued and sought after as the "Opus Anglicanum" of the thirteenth century. Here is a splendid work for our war-disabled men to start upon.

NETTLE-GROWING FOR TEXTILE MANUFACTURE.

Attention is drawn in the "Economic Supplement" to the *Daily Review of the Foreign Press* to an article in the *Frankfurter Zeitung* (July 31st) on Nettle Cultivation. Fifty years ago the fibre was still in common use in Germany, and cotton was looked at askance as the substitutes are to-day. Thanks to the researches of the Saxon textile manufacturer Wilde and other experts, the complete isolation of the fibre has been achieved, and under his guidance the Nettle Cultivation Society has been formed, which is now working with a capital of Mk.15 mill. Till peace is signed it is organised as a public utility undertaking, and will only emerge as a profit-making enterprise thereafter. Several plantations have already been made, at Zehlendorf near Berlin, at Nauen near Havelluch, and elsewhere. It was formerly imagined that the nettle would only thrive in partly shaded localities; it has been found that as long as the soil is sufficiently rich in nitrogen and sufficiently moist, the cultivation is extremely easy and yields abundant harvests. As the nettle is a perennial plant, it is only at the outset that money and labour are necessary. It may be raised from seed or cuttings, and as its roots throw out many runners, the cuttings may be set out at comparatively wide intervals. The leaves furnish a nutritious fodder, the woody fibre good blotting-paper, and possibly other by-products may be obtained in future. Of course it will be impossible at once to replace the Mk.600 mill. of cotton which Germany used to import; much of that was again exported in the form of various fabrics; the important thing is how to meet the home demand—the general public can help by gathering the wild nettle. Four kilogs of dried stalks are sufficient to make a soldier's shirt, and are worth Mk. 1.12.

It is impossible to say whether the manufacturers will return to cotton after the war if there

is a favourable market. But it would be well if Germany were able to make herself independent of America in this regard.

The *Vossische Zeitung* (July 26th) states the best variety of the nettle is the *Urtica dioica*, a large plant which reaches a height of nearly 2 m. The company mentioned above now possesses 28,000 hectares of land, and experiments have shown the best methods of planting and cultivating the nettle, as well as the best process of obtaining the fibre. The bast fibres which surround the woody stem of the plant are fastened together by a kind of glutinous substance. This must be removed before the fibre can be spun. This is comparatively simple. Between 2¼ and 2½ m. of material are yielded by 4 kilogs of dried nettles, and 1 kilog of nettle-fibre is but little dearer than 1 kilog of cotton. The sum of Mk.25 is paid for 100 kilogs of dried stalks and Mk.10 for 50 kilogs of leaves which, owing to their large protein content, are valuable for fodder.

GENERAL NOTES.

THE MAHARANI OF BHAVNAGAR.—The death recently occurred of that enlightened princess, Nandkunverba, Maharani of Bhavnagar, C.I. Her Highness had almost completed for publication Gujarati, Hindi and Urdu translations of five of the earlier and more important of Mr. Lloyd George's war speeches, and these, together with the English text, have been issued in the form of a neatly-printed volume by the Bhavnagar State Press at the price of Rs. 5. The headings given by the translator to the various speeches are as follows: "Through Terror to Triumph," "The Righteousness of our Cause," "A Holy War," "The Appeal to the Workshop," and "Peace at Home." In accordance with the intention of the Maharani, the money realised by the sale of the work will be devoted to charitable purposes. Her Highness had previously published an excellent appreciation, consisting of some 120 pages, in English, of the late Lord Kitchener, in which she expressed the belief that if, as the result of the part taken by Indian soldiers in the great war India should be given "equality of treatment and of responsibility" these privileges will be largely owing to him. The Maharaja of Bhavnagar is a Life Fellow of the Society, having been elected in 1885.

NEW FABRICATED SHIP.—Sir W. G. Armstrong, Whitworth & Co., Ltd., have just delivered from their Walker shipyard their first fabricated ship, designed by themselves. She is constructed, according to *Engineering*, on the Isherwood system of longitudinal framing, and has a carrying capacity of 10,000 tons. The keel was laid on March 11th, 1918, and the vessel was launched on September 5th, the total time from keel-laying to handing over being thirty-one weeks and five days. Circumstances beyond the control of the builders interfered with the work of completion, or the vessel would have been finished a month earlier. The experiment in fabrication was, however, very satisfactory, and promises well for dispatch in the building of the rest of the ships of the series at this yard.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

JANUARY 29.—FREDERICK KEEBLE, C.B.E., M.A., Sc.D., F.R.S., Controller of Horticulture, Food Production Department, "Food Production by Intensive Cultivation." LORD LAMBOURNE, C.V.O., will preside.

FEBRUARY 5.—EDWARD CARSTENSEN DE SEGUNDO, A.M.I.C.E., M.I.Mech.E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes." LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

FEBRUARY 12.—SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

FEBRUARY 19.—JOHN FRANCIS CROWLEY, D.Sc., A.M.I.E.E., "The Use of Electricity in Agriculture in Germany." SIR JOHN F. C. SNELL, M.Inst.C.E., will preside.

FEBRUARY 26.—W. L. HICHENS (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry." W. A. APPLETON, C.B.E., Secretary, General Federation of Trade Unions, will preside.

MARCH 5.—B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

MARCH 12.—

MARCH 19.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

FEBRUARY 13.—

MARCH 13.—

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

FEBRUARY 25.—EDWARD J. DUVEEN, Fellow of the Royal Statistical Society, "Key Industries."

MARCH 4.—PROFESSOR JOHN CUNNINGHAM McLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

MAY 27.—SIR EDWARD R. DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced :—

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. N. SPENCER WILLIAMS, "The Hawaiian Islands and their Industries."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

W. NORMAN BOASE, "Flax."

LEONARD ERSKINE HILL, M.B., F.R.S., "Housing and Infant Mortality."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

J. A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

Syllabus.

LECTURE I.—FEBRUARY 10.—Electromagnetic waves—Æther theories: Maxwell's electromagnetic theory of light—Hertzian waves—Aerials and radiators in modern wireless telegraphy—Methods of creating damped and undamped waves for radiotelegraphy.

LECTURE II.—FEBRUARY 17.—The transmission of long electromagnetic waves over sea and land—Penetration of high-frequency currents into conductors—The attenuation of radiotelegraphic waves—Diffraction of such waves round the earth—Effects of the atmosphere—Long-distance stations.

LECTURE III.—FEBRUARY 24.—The detection of electromagnetic waves — Magnetic, electrolytic, thermionic, and crystal detectors — Receiving arrangements—The development of the thermionic detector—The Fleming valve—The three-electrode valve in radiotelegraphy and radiotelephony.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JANUARY 27...Engineers, Junior Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.30 p.m.

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Geographical Society, Burlington-gardens, W., 8 p.m. Commander S. Simson, "The Tanganyika Expedition."

TUESDAY, JANUARY 28...Industrial Reconstruction Council, 2, Tudor-street, E.C., 6 p.m. Mr. M. W. Jenkinson, "The Worker's Interest in Costing (a Factor of Industrial Reconstruction)."

Royal Institution, Albemarle-street, W., 3 p.m. Professor S. Wilkinson, "Lessons of the War." (Lecture III.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Hon. R. C. Parsons, "Centrifugal Pumps for dealing with Liquids containing Solid, Fibrous and Erosive Matters."

Anthropological Institute, 50, Great Russell-street, W.C., 5 p.m. Presidential Address, "War and Anthropology."

Colonial Institute, Hotel Cecil, Strand, W.C., 4 p.m. Colonel C. M. Long, "The Australian Service Man as a Citizen."

WEDNESDAY, JANUARY 29...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. F. Keeble, "Food Production by Intensive Cultivation."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.45 p.m. Captain R. J. G. Crouch, "The Rigging of Aeroplanes."

Church Crafts League, Church House, Westminster, S.W., 3 p.m. Sir Cecil H. Smith, "War Memorials."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Captain T. Carnwath, "Lessons of the Influenza Epidemic."

THURSDAY, JANUARY 30...Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution Albemarle-street. W., 3 p.m. Professor J. N. Collie, "Chemical Studies of Oriental Porcelain." (Lecture III.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. W. Sanderson, "Southern Italy."

FRIDAY, JANUARY 31...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor H. H. Turner, "Giant Suns."

SATURDAY, FEBRUARY 1...Royal Institution, Albemarle-street, W., 3 p.m. Professor H. P. Allen, "The Works of J. S. Bach." (Lecture I.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—January 24, 1919.

No. 3454. JANUARY 31, 1919. Vol. LXVII

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers over three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2)

Journal of the Royal Society of Arts.

No. 3,454. VOL. LXVII.

FRIDAY, JANUARY 31, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, FEBRUARY 5th, at 4.30 p.m. (Ordinary Meeting.) EDWARD CARSTENSEN DE SEGUNDO, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes." LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

SEVENTH ORDINARY MEETING.

Wednesday, January 29th, 1919; LORD LAMBOURNE, C.V.O., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Bitterling, Charles Frederick Augustus, Nottingham.
Hammick, Sir Murray, K.C.S.I., C.I.E., London.
Hetherington, John, London.
Hubbard, Major Reginald Kirshaw, R.A.S.C., B.E.F., France.
Hugon, John Herbert, A.I.M.M., A.R.S.M., Withington, Manchester.
Major, Mark B. F., London.
Rose, Cav. Ing. Henry G., Genoa, Italy.
Stevenson, William, F.C.S., London.
Whitaker, George Herbert, M.R.C.S., L.S.A., London.
Williams, Geoffrey Sydney, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Baker, Charles John, Shrewsbury.
Barnes, Cecil James, London.
Beardsell, Arthur M., Huddersfield.
Benson, Philip de Gylpyn, B.Sc., London.
Bergesen, Sigval, Stavanger, Norway.
Berry, Charles Walter, London.
Blackmore, Alfred, London.
Borgen, Christian, Stavanger, Norway.
Brain, Sir Francis William Thomas, M.Inst.C.E., Bristol.
Brooke, Herbert, London.
Burt, C. Harley, London.
Carroll, Anthony Joseph, Chester.
Carter, Robert Radcliffe, Walsall.
Connell, John, Glasgow.
Constable, Archibald James, Littlehampton.
Cooke, Harry, Leeds.
Cuttriss, Charles Arthur, Rangoon, Burma.
Dickson, William Collins, Glasgow.
Duveen, Edward J., London.
Elkan, Baron, London.
Evens, Walter, Westcliff-on-Sea.
Falck, Hans L., Stavanger, Norway.
Fogarty, Laurence Francis Alexander, Ruislip.
Fraser, Stewart, Cairo, Egypt.
Hepworth, Cecil M., Walton-on-Thames.
Hill, Norman, Coventry.
Hopkinson, Edward, M.A., D.Sc., M.P., Alderley Edge, Cheshire.
Iden, Walter J., M.I.Mech.E., London.
Lal, Kunwar Nand, Benares, India.
Leaver, Cyril D'Arcy, Harpenden, Herts.
Morton, T. M. Gray, M.I.Mech.E., Wishaw.
Neagle, William, B.Sc., Erith, Kent.
Niblett, Lieut.-Colonel Herbert, D.S.O., Farnham Royal, Bucks.
Palmer, Henry William Hetherington, F.R.I.B.A., London.
Reeves, Arthur William, Birmingham.
Ross, Major Andrew A., R.A.F., London.
Rossiter, Alfred, Luton.
Rush, Lieut. Charles Henry Erskine, A.M.I.Mech.E., M.I.A.E., London.
Ryan, Cecil Godfrey, Tasmania.
Smellie, James, Dudley.
Spalding, Walter, London.
Taylor, Richard Henry, O.B.E., London.
Trench, E. F. C., M.Inst.C.E., London.

A paper on "Food Production by Intensive Cultivation" was read by Frederick Keeble, C.B.E., M.A., Sc.D., F.R.S., Controller of Horticulture, Food Production Department.

The paper and discussion will be published in a subsequent number of the *Journal.*

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, January 16th, 1919: Sir Charles H. Armstrong, Chairman, Great Indian Peninsula Railway, in the chair.

The paper read was—

THE CARRIAGE OF COAL BY RAIL IN INDIA.

By H. Kelway-Bamber, M.V.O., M.Inst.Loco.E.,
Late Superintendent of Rolling Stock, East Indian Railway.

Introductory.

There are to-day many indications of an active development of Indian industries, and the Indian Industrial Commission, which has been sitting for the past two years under the chairmanship of Sir Thomas Holland, K.C.I.E., finds, among other things—

(*a*) That India is a country rich in raw materials.

(*b*) That industrial possibilities are good, but manufacturing prospects poor.

(*c*) That Indian labour is inefficient, but capable of vast improvement; and

(*d*) That Indian coal is generally poor in quality, thus limiting the radius within which it can be economically used.

Energetic Government intervention in Indian industrial affairs is advocated, and proposals are made for the creation of Imperial and Provincial Government departments.

These recommendations, if acted upon, will result in a greatly increased demand for coal, and accentuate the necessity for cheap transport of fuel over the great distances separating the principal coalfields from Indian ports and cities; and the object of this paper is—

(*a*) To show the past development in Indian coal output;

(*b*) To forecast future coal consumption; and

(*c*) To suggest means for reducing the already low cost of coal transport by rail in India.

Coal Resources.

A recent inventory of the world's coal resources placed before the International Geological Congress held in Canada in 1913 gave the following particulars:—

The World's Coal Resources.

Continent.	Millions of tons.	Per cent.
North America . .	5,073,426	68·50
Asia	1,279,586	17·32
Europe	784,190	10·62
Australia and Oceania	170,410	2·35
Africa	57,839	0·78
South America . .	32,102	0·43
Total . .	7,397,553	100·00

The details of Asia's coal resources are:—

Coal Resources of Asia.

Country.	Millions of tons.	Per cent.
China	995,587	77·77
Siberia	173,879	13·60
India	79,001	6·17
Indo-China	20,002	1·59
Japan	7,970	·62
Persia	1,858	·15
Manchuria	1,208	·10
Korea	81	—
Total . .	1,279,586	100·00

According to these figures, India's coal deposits are ten times as great as those of Japan, less than half those of Siberia, and about one-twelfth those of China.

South African resources are estimated in the same inventory at 56,200 million tons, or three-fourths those of India.

The industrial progress of nations can best be measured by their coal production, and especially by their coal consumption, and the vast progress of the Anglo-Saxon nations and of Germany in the manufacturing industries, commerce, wealth, strength, and population is attributable to their remarkable preponderance in coal supplies.

World's Output of Coal.

The output of the world's principal coal-producing countries for 1913, the last year of

work under normal conditions before the outbreak of the great war, is shown below.

World's Coal Output for the Year 1913.

Country.	Millions of tons.	Per cent.
United States	504·52	38·20
United Kingdom . . .	287·41	21·76
Germany	273·65	20·72
Austria-Hungary . . .	51·58	3·91
France	40·19	3·06
Russia	29·87	2·26
Belgium	22·50	1·63
Japan	20·97	1·60
India	16·21	1·23
South Africa. . . .	8·48	·65
Other	65·62	4·98
Total . .	1321·00	100·00

India's coal output for the year, it will be seen, was less than one-thirtieth that of the United States, one-seventeenth that of the United Kingdom and of Germany respectively, about twice that of South Africa, and four-fifths that of Japan.

The development in the coal output of the United States, the United Kingdom, Germany and India during the twenty-nine years 1885–1913 is shown below.

Development in Coal Output
(millions of tons).

Years.	United States.	United Kingdom.	Germany.	India.
1885 .	102·2	162·0	73·7	1·3
1895 .	177·6	194·3	104·0	3·5
1905 .	351·1	239·9	173·7	8·4
1913 .	504·5	287·4	273·6	16·2

It will be seen that in about twenty years the United States trebled its annual coal output, the increase in the United Kingdom for the same period being less than 50 per cent.

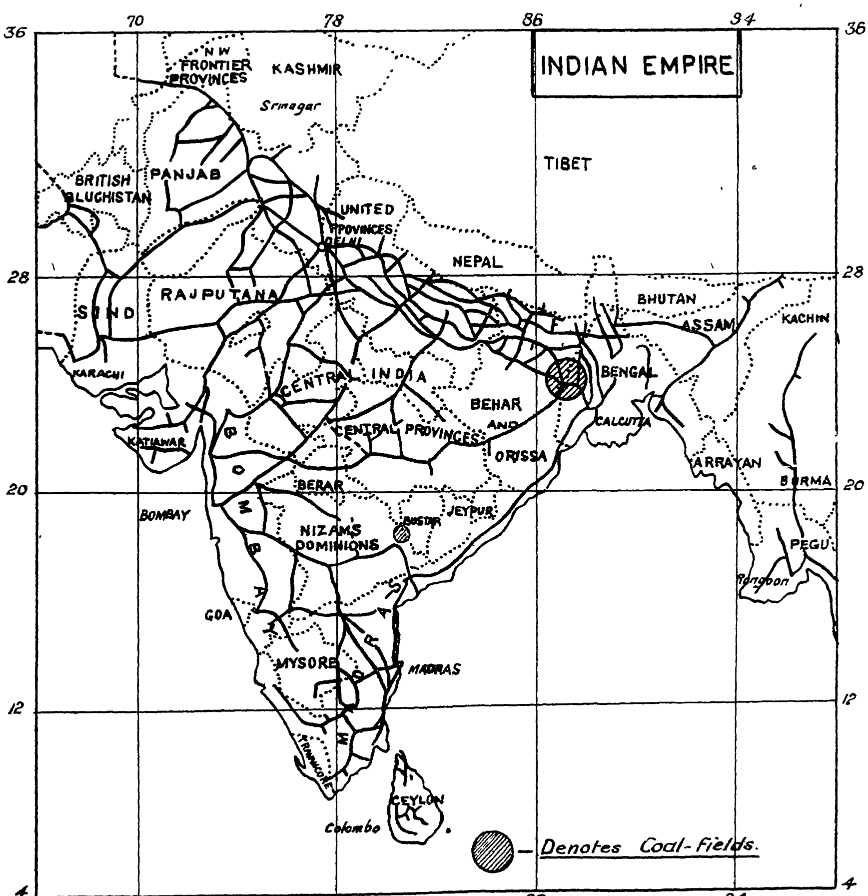


FIG. 1.

Germany's output meanwhile increased by nearly 163 per cent., and at the outbreak of war was practically equal to that of the United Kingdom.

India's output for 1913 was exactly *one-tenth that of the United Kingdom twenty-nine years ago.*

The relative progress in the coal output of Japan, India and South Africa for the sixteen years 1900–1915 is shown below.

Progress in Coal Output
(millions of tons).

Years.	Japan.	India.	South Africa.
1900 . . .	7·37	6·12	—
1905 . . .	11·41	8·42	3·67*
1910 . . .	15·43	12·05	7·11
1915 . . .	22·50	17·10	10·07

From the statement it will be seen that during the decade 1906–1915 the outputs of the three countries increased thus:—

Japan . . . . . = 100 per cent.
India . . . . . = 100 „
South Africa . . = 150 „

India, with coal resources estimated to be ten times as great as those of Japan, has in the matter of output shown no tendency during the decade 1906–1915 to vie with or to overtake her Eastern coal competitor.

Having briefly reviewed India's position among coal-producing countries, we may now proceed to consider more closely her individual development during the first fifteen years of the present century.

India's Coalfields.

Of the numerous coalfields of proved value in India, eighteen are actually being worked, but only seven are of any considerable importance, and 91 per cent. of the total Indian output for 1916 was produced in the Raniganj and Jherria fields, the positions of which are shown in Fig. 1.

The explanation is that most other coalfields are too remote from ports and existing centres of industry to make it possible for their produce to be carried to places where it would have to compete with fuel from the premier coalfields of Bengal.

The principal Indian coalfields and their output for the year 1916 were as follows:—

* Output for 1904.

Godwana Fields.

District.	Output in 1916 (millions of tons).	Percentage of total output.	
Bengal, Bihar and Orissa—			
Jherria . . .	8·95	51·87	Per cent. 84
Raniganj . . .	5·53	32·09	
Giridih . . .	·87	5·02	
Ramgarh Bokaro	·20	1·14	91·33
Daltonganj . .	·075	·44	
Jainty . . .	·075	·44	
Sambalpur . .	·06	·33	
Central India—			
Umaria . . .	·20	1·16	1·16
Central Provinces—			
Pench Valley .	·16	·90	
Ballarpur . .	·08	·49	1·67
Mohpani . . .	·05	·28	
Hyderabad—			
Singareni . .	·61	3·58	3·58
Total . . .	16·86	97·74	97·74

Tertiary Fields.

District.	Output in 1916 (millions of tons).	Percentage of total output.	
Baluchistan—			
Khost	·03	·19	
Sor Range . . Mach, etc. . .	·009	·05	·24
Assam—			
Makim, etc. .	·281	1·66	1·66
North Western Frontier Province—			
Hazari . . .	·001	—	—
Punjab (Salt Range)—			
Jhelum District .	·04		
Shahpur . . .	·01	·28	·28
Mianwali . . .	·008		
Rajputana—			
Bikanir . . .	·014	·08	·08
Total . . .	·392	2·26	2·26
Brought forward .	16·860	97·74	97·74
	17·252	100·00	100·00

It will thus be seen that about 97·7 per cent. of the coal supplies of India is obtained from the Godwana coalfields, and 2·3 per cent. from the Tertiary beds.

The Raniganj field, opened in 1820, and the Jherria field, opened in 1893, are in the Damuda Valley and produce 84 per cent. of the total output of Indian coal.

The Raniganj field chiefly within the district of Burdwan (Bengal) covers an area of 500 square miles, and as will be noted from the figures given above its yield in 1916 (5.535,300 tons), was equal to 32 per cent. of India's total coal production for the year.

The Jherria field in Bihar and Orissa with an output of 8,950,300 tons in 1916 produced 52 per cent. of the total.

Outside Bengal, Bihar, and Orissa the most important mine is the Singareni near Yellunda in the Hyderabad State.

Opened in 1887, the average amount produced annually for the last ten years has been 510,000 tons; its output in 1916 was 615,000 tons.

Value of Coal.

The value of the coal produced in India is reported annually by mine-owners, and the figures represent the actual or estimated wholesale price of coal at the pit's mouth.

The average value per ton of coal produced for the mines in Bengal, Bihar, and Orissa during the sixteen years 1901–1916 has been as follows:—

	Average of five years. Rup.	Ann.	s.	d.
1901–1905 . .	2	5	3	1
1906–1910 . .	3	4	4	4
1916 (one year)	3	6	4	6

With the above may be compared the value at the pit's mouth of coal produced in other countries, and the following figures represent the average for the latest five years for which statistics are available.

Country.	Rup.	Ann.	Pies.	s.	d.
India . . .	3	6	10	4	6·83
South Africa .	4	4	10	5	0·83
United States of America . .	4	8	7	5	4·60
Japan . . .	4	15	10	5	11·83
Australia . .	5	9	5	7	5·42
United Kingdom	7	7	10	9	11·83
Germany . .	7	12	4	10	4·33
France . . .	9	6	11	12	6·92

It will thus be seen that the average price of Indian coal at the pit's mouth is considerably less than half that of coal produced in the United Kingdom, its nearest competitor, in point of price, being South Africa.

In comparing average values of coal raised in different countries, it must be remembered that price is affected by various circumstances, such as the quality, accessibility, machinery in use, difference in cost of labour, and difference in cost of transport.

In India the coal now being worked is comparatively near the surface; labour is also comparatively cheap; it has, therefore, a lower value at the pit's mouth than the coal of any other country.

Output of Coal.

India's progress and the Bengal fields' share in the total coal output for the period 1900–15 are shown below.

Coal Output in Millions of Tons.

Years.	India's total output.	Output of Bengal coalfields.	Bengal's percentage of total output.
1900 . . .	6·12	4·98	81·35
1905 . . .	8·42	7·23	85·75
1910 . . .	12·04	10·78	89·53
1915 . . .	17·10	15·70	91·81

From the following figures it will be noted, chiefly for the reasons already given, how slow has been the progress in output of other Indian coal-mines.

Years.	India's total output.	Output of Bengal coalfields.	Output of other coalfields.
1900 . . .	6·12	4·98	1·14
1905 . . .	8·42	7·23	1·19
1910 . . .	12·09	10·78	1·26
1915 . . .	17·10	15·70	1·40

About 30 per cent. of India's total present coal output is consumed by locomotives or in locomotive and other Indian railway works, and 17 per cent. is exported, of which about two-thirds goes to ports outside India; the distribution of the output for the year 1913 has been roughly estimated to be—

	Per cent.
Railways (including workshops)	31·1
Consumption at collieries and wastage	10·1
Cotton mills	7·3
Brick and tile manufactories	7·0
Bunker coal	6·7
Jute mills	4·8
Iron and brass foundries	4·7
Inland steamers	3·8
Port Trusts	1·0
Tea gardens	0·9
Other forms of industrial and domestic consumption	22·6
Total	100·0

For a population in 1915 of, say, 320 million people, a coal consumption of 17·1 million tons in industrial and domestic and other purposes represented about 0·05 tons weight or 90 lb. per head of population per annum.

In 1912 the United Kingdom produced about 7 million tons of steel requiring for its manufacture the consumption of, say, 21 million tons of coal; Germany produced 17 million tons of steel, requiring 51 million tons of coal, while in the same year the United States steel outturn was 31,251,000 tons requiring the consumption of 93,753,000 tons of coal.

As India has large resources of iron ore, coal stores estimated at 79,001,000,000 tons and a population of 320,000,000, there will be plenty of scope for the energies of the industrial people of the country for many years to come.

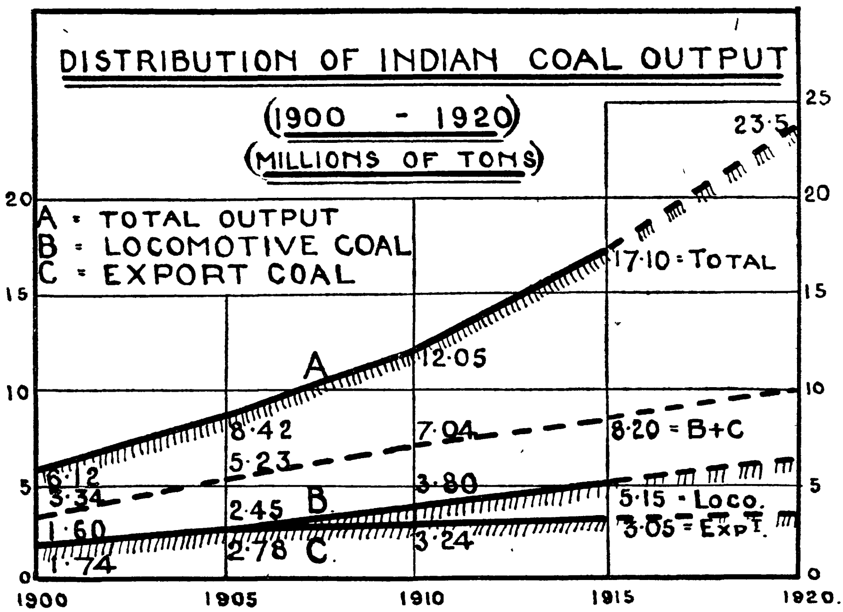


FIG. 2.

The quantity accounted for in this manner and the balance available for industrial and other purposes in India are shown below and graphically at Fig. 2.

Coal Output in Millions of Tons.

Years.	India's total coal output.	Coal used by railways and exported.	Balance available for other purposes.	Percentage of balance to total output.
1900	6·12	3·34	2·78	45·4
1905	8·42	5·23	3·19	37·8
1910	12·05	7·04	5·01	41·6
1915	17·10	8·20	8·90	52·0

Rail-borne Coal.

The aggregate weight of coal carried for the public and for foreign lines on all Indian railways during the year 1915–16 amounted to 19 million tons, or about 30 per cent. of the total aggregate weight (64·14 million tons) of goods and minerals loaded into goods wagons during that year.

The relation of the coal to the total goods and mineral traffic of India for the ten years 1905 to 1915–16 is shown below.

All Indian Railways.

Goods and mineral traffic—weight lifted 1905 to 1915–1916 (millions of tons).

Year.	Goods and minerals.	Coal.	Percentage of coal to total goods and mineral traffic.
1905 . .	40·73	10·20	25·55
1910 . .	50·23	13·91	27·69
1913–14 .	62·54	17·17	27·43
1915–16 .	64·14	19·06	29·72

It will be noted that while the aggregate weight of goods and minerals lifted during the period has increased by 57 per cent., the aggregate weight of coal carried increased by 90 per cent.

Receipts from Coal Traffic.

Receipts from coal carried for the public and for foreign railways for the year 1915–16 amounted to 631 lacs (£4,200,000), or over 17·56 per cent. of the total goods earnings of all Indian railways.

The relation of coal to the total goods and mineral receipts for all Indian railways is shown below.

All Indian Railways.

Total goods and mineral traffic receipts for the period 1905 to 1915–1916 (lacs of rupees).

Year.	Goods and mineral receipts.	Coal receipts.	Percentage of coal to total goods and mineral receipts.
1905 . .	24·42	2·90	11·83
1910 . .	28·40	3·85	13·57
1913–14 .	35·01	4·97	14·20
1915–16 .	35·93	6·31	17·56

It will thus be seen that coal representing 30 per cent. of the total goods lifted and 17·56 per cent. of the total goods receipts is a very important element in Indian railway goods traffic as a whole.

Coal Traffic on the East Indian and Bengal Nagpur Railways.

The coalfields of Bengal, Bihar and Orissa are served by the East Indian and Bengal Nagpur Railways, and are in direct communication by rail with all parts of India; their positions have already been shown in Fig. 1.

Including that used for working their respective railways, the total weight of coal loaded into wagons on the East Indian and Bengal Nagpur Railways during the period 1900 to 1915–16 averaged 91 per cent. of the total weight of coal raised in India during that period: the details are shown below.

Total weight of coal loaded into wagons on the East Indian and Bengal Nagpur Railways. (millions of tons).

	1900.	1905.	1910.	1915-16.
E.I.R. . .	5·12	6·65	8·42	10·60
B.N.R. . .	0·86	1·71	2·51	3·74
Total . .	5·98	8·36	10·93	14·34
India's output	6·12	8·42	10·78	17·10

Note.—As an interesting comparison, the figures for the total quantity of coal and coke (14·34 million tons) loaded into wagons during 1915 on the East Indian and Bengal Nagpur Railways are shown below in relation to the weight of coal and coke loaded on the principal coal-carrying railways of Great Britain during 1913. It will be seen that the weight was approximately that of coal loaded on the Great Central Railway of this country in 1913.

The distance over which coal is hauled in India is, however, from six to eight times as great as in this country.

Railway.	Quantity carried for the public (millions of tons).	Percentage of total loaded.
North Eastern	41·50	18·3
Midland	27·83	12·2
London and North Western	23·50	10·3
Great Western	22·14	9·8
North British	21·23	9·4
Taff Vale	15·68	6·9
Great Central	14·92	6·6
[*East Indian and Bengal Nagpur Railways*] . .	[*14·34*]	[*6·3*]
Caledonian	13·03	5·7
Lancashire and Yorkshire	9·40	4·1
Great Northern	8·74	3·9
Other Railways	28·97	12·8
Total . .	226·94	100·0

If the progress in India's coal output continues at the same rate as during the past

fifteen years, then by 1930, as shown in Fig. 3, the total output should amount to 36 million, and by 1950 to 60 million tons, of which 40,000,000 tons should be available for domestic and other purposes.

By that time the population of India should be approximately 400,000,000 people, so that the coal consumption per head of population would amount to 0·15 of a ton, or about 336 lb. compared with from four to five tons per head, the average consumption per head of population in Great Britain and America respectively immediately before the outbreak of war.

The average coal consumption per head for these and other countries is shown in the following statement:—

ANNUAL CONSUMPTION OF COAL PER HEAD OF POPULATION IN TONS (2,240 LB.)

Country.	1901-5. Annual average tons.	1906-10. Annual average tons.	1911. Tons.	1912. Tons.	1913. Tons.
United States of America	3·67	4·43	4·54	4·82	5·02
United Kingdom	3·93	4·04	4·08	3·83	4·11
Belgium	2·82	3·10	3·21	3·35	—
Canada	1·88	2·59	3·03	3·32	3·65
New Zealand	1·72	2·07	2·00	2·23	2·00
German Empire	1·69	2·00	2·00	2·12	—
Australia	1·34	1·42	1·65	1·71	1·81
France	1·15	1·34	1·44	1 48	1·58
South Africa	—	·77	·92	·95	·92
Austria-Hungary	·39	·49	·52	—	—
Russian Empire	·15	·18	·19	·21	·23
India	·02	·04	·04	·05	·05

From the figures in the above statement it will be seen that there is plenty of scope for an increased consumption of coal in India per head of population, before it in any way approaches even that of the Russian Empire.

INDIAN RAILWAY (B.G.) COAL WAGONS.

For various reasons the standard coal-carrying wagon on Indian broad-gauge (5 ft. 6 in.) railways has been a four-wheeled, flat bottom, open vehicle, its load being discharged either mechanically by end-tipping, or by hand labour through side doors.

The policy of railway authorities especially with regard to Indian broad-gauge wagon-carrying capacity has been progressive, the coal-carrying capacity having since 1895 increased from 12·5 to 20 and 23·5 tons for a dead weight of 6·0, 8·4 and 8·75 tons respectively, the two latter being equipped with vacuum brakes.

Wagons of 23·25 tons coal-carrying capacity represent the present high-watermark of Indian broad-gauge railway practice, their gross weight amounting to 32 tons, or 16 tons per pair of wheels on rail.

WAGON LOADS.

The average coal-carrying capacity of all Indian broad-gauge railway wagons is approaching 18 tons, but the large additions to stock shortly to be made should soon raise the average to 20 tons.

At that figure the coal traffic of India will by 1930 need three times, and by 1950 five times the number of vehicles that were required to handle the traffic of the year 1910.

Those conversant with the congestion ensuing in times of pressure in Indian coal districts will appreciate what is before them even ten years hence.

American practice favours a 60-ton wagon with a 20-ton tare, a gross weight of 80 tons or 20 tons per pair of wheels on rail.

The very beneficial results attending the use of high-capacity wagons in handling coal traffic are shown by the figures in the following statement, which have been based upon the actual total Indian coal output of the year 1910, and the prospective outputs of the years 1930 and 1950.

TOTAL OUTPUT AND NUMBER OF LOADS IN MILLIONS.

Years.	Total coal output.	Number of loads for wagons of various capacities to move the year's output. Coal capacity of wagons in tons. 16·0	20	23·25	50	60
1910	12·0	·750	·600	·515	·240	·200
1930	36·0	2·250	1·800	1·584	·720	·600
1950	60·0	3·750	3·333	2·584	1·200	1·000

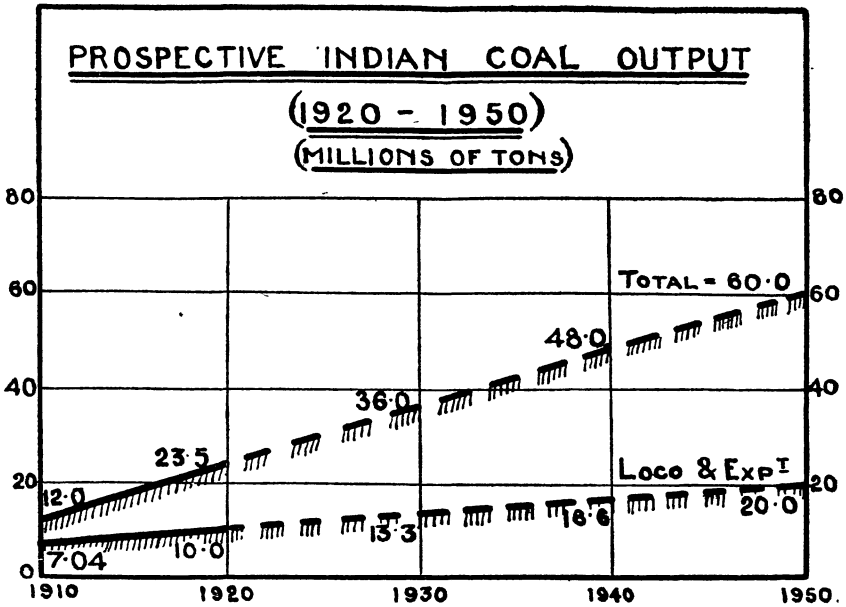


FIG. 3.

Years.	Total coal output (millions of tons).	Average number of wagons of various capacities to be loaded daily during a working year of 300 days to move the total coal output. Coal capacity of wagons in tons. 16·0	20	23·25	50	60
1910	12·0	2,500	2,000	1,717	800	666
1930	36·0	7,500	6,000	5,280	2,400	2,000
1950	60·0	12,500	11,111	8,610	4,000	3,333

From the statement given above, and from Fig. 4, it will be seen that the use of such vehicles in place of 23¼-ton wagons would reduce the number of wagons to be handled in 1930 and 1950 by about 62·0 per cent., the actual number of loads being reduced in 1930 from 1,584,000 to 600,000, and in 1950 from 2,584,000 to 1,000,000.

FREIGHT RATES.

In 1905 the minimum to which Indian

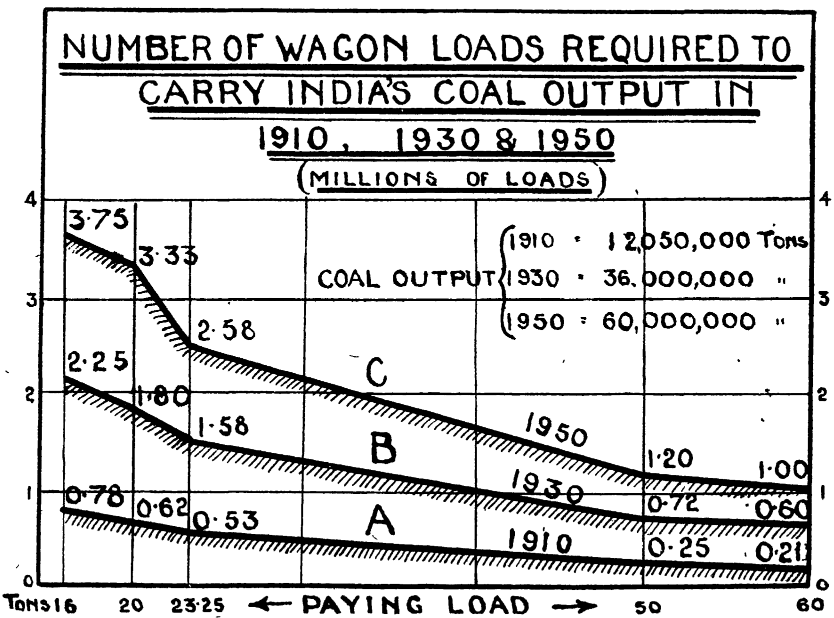


FIG. 4.

railways were permitted to reduce their rates for the carriage of coal was fixed as follows :—

Distance.	Per maund (82·22 lb.) per mile.
	Pies.
Up to 300 miles	0·100
From 300 to 500 miles	0·075
In excess of 500 „	0·050

Note.—27·22 maunds = 1 ton. 1 pie = $\frac{1}{12}d.$

The English equivalent in pence per ton-mile of these rates is :—

Distance.	Rate per ton per mile.
	Pence.
Up to 300 miles	·2268
From 300 to 500 miles	·1701
In excess of 500 „	·1134

The approximate cost of freight at minimum rates to be added to free-on-rail prices for coal for various distances in Indian and English currency is as follows : —

Approximate cost of freight per ton (2,240 *lb.*) *mile.*

Distance in miles.	Freight in Indian currency.		Freight in English currency.	
	Rs.	Annas.	s.	d.
100 . . .	1	$6\frac{5}{8}$	1	$10\frac{5}{8}$
150 . . .	2	2	2	11
300 . . .	4	4	5	8
500 . . .	6	6	8	6
750 . . .	8	2	10	$10\frac{1}{2}$
1,000 . . .	9	14	13	$2\frac{3}{4}$
1,250 . . .	11	12	15	8

Note.—1 rupee = 16*d.* 1 anna = 1*d.*

The railway freight for coal raised in the Jherria fields and carried to the principal Indian cities is :—

City.	Approximate distance from Jherria fields.	Freight per ton in Indian currency.			Freight per ton in English currency.	
	Miles.	Rup.	Ann.	Pies.	s.	d.
Calcutta .	180	3	2	0	4	2
Cawnpore .	460	5	15	0	7	11
Jubbulpore	545	6	11	0	8	11
Delhi . .	725	7	15	0	12	7
Lahore .	1000	9	13	0	13	1
Bombay .	1120	12	2	0*	16	2

* Freight to August, 1916, was Rs. 11 Annas 4.

The average price of Jherria coal at pit's mouth in 1916 being Rs. 3 Annas 6 (*i.e.* 4*s.* 6*d.*) per ton, it will be seen that freight to Calcutta nearly doubles, to Cawnpore trebles, and to Lahore about quadruples the pit mouth cost to the consumer.

High-capacity Wagons.

A matter of first-class importance, especially where distances are so great as in India, is the percentage *of paying or net load to gross weight moved*, not only in regard to the loaded, but also of the return journey, frequently made with little if any freight.

The advantage attending the use of high-capacity wagons in this respect will be seen from the following statement :—

Paying load.	Dead weight.	Gross weight.	Percentage paying load to gross weight. Loaded journey.	Loaded and empty journey.
Tons.	Tons.	Tons.	Per cent.	Per cent.
10·00	6·00	16·0	62·5	45·5
16·00	8·00	24·0	66·6	50·0
20·00	8·40	28·4	70·4	54·5
23·25	8·75	32·0	72·6	57·0
60·00	20·00	80·0	75·0	60·0

The relation is shown graphically in Fig. 5, in which, however, two four-wheeled wagons have been combined as one bogie vehicle to facilitate comparison.

Coal Trains.

The gross weight of coal trains on the East Indian and Bengal Nagpur Railway ranges from 1,300 to 1,500 tons—say, 1,400 tons mean.

The number of wagons required to make up this load will vary with their coal-carrying capacity in the following manner :—

Coal-carrying capacity of wagon.	Dead weight of wagon.	Gross weight of wagon.	No. of wagons in a 1,400-ton train
Tons.	Tons.	Tons.	No.
*10·00	6·0	16·0	87·5
16·00	8·0	24·0	58·5
20·00	8·4	28·4	49·3
23·25	8·75	32·0	44·8
50·00	18·0	68·0	20·6
60·00	20·0	80·0	17·5

* The majority of British railway coal wagons have a capacity of 10 tons. On Indian broad-gauge railways few coal wagons have a capacity of less than 16 tons. The figures have been included merely for the purpose of comparison.

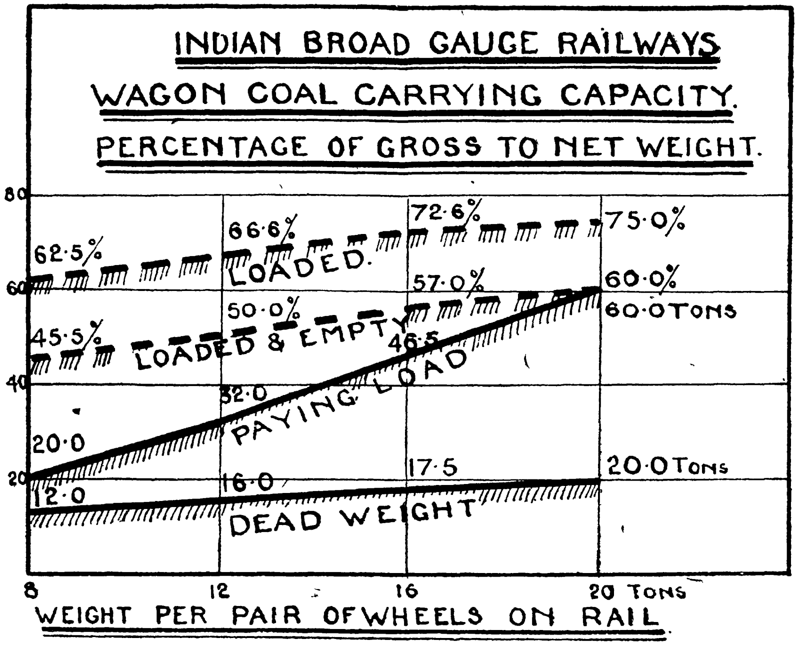


FIG. 5.

DISTANCE HAULED.

The average distance over which a ton of coal was hauled on Indian railways before the war was approximately 250 miles, and the earnings of trains composed of wagons of increasing capacities and of a gross weight of 1,400 tons are shown in the following statement:—

GROSS EARNINGS OF A TRAIN WEIGHING 1,400 TONS, AND CARRYING COAL A DISTANCE OF 250 MILES.

Coal-carrying capacity of wagon.	Number of wagons in a train.	Weight of coal in a train.	Gross earnings.	
			Indian currency.	English currency.
Tons.	Number.	Tons.	Rupees.	£
16	58·3	933	3,660	224·0
20	49·3	986	3,487	232·4
23·25	44·8	1,042	3,684	245·6
60	17·5	1,050	3,712	247·5

It will be noted, from the above statement, that the latest type of Indian broad-gauge wagon (Fig. 6) of 23¼ tons coal-carrying capacity has, for a given train-weight, a revenue earning power about equal to that of up-to-date American vehicles.

Assuming the continuance of 1,400 tons as the mean gross weight of Indian coal trains, then the number of trains required to move the total Indian coal output of 1930 and 1950 respectively, compared with 1910, and the average number of loaded coal trains despatched from collieries daily, would be as follows:—

Coal carrying capacity of wagon.	Weight of coal in a train.	Number of trains required to move the total Indian coal output.		
		1910. Tons. 12,050,000	1930. Tons. 36,000,000	1950. Tons. 60,000,000
Tons.	Tons.	Trains.	Trains.	Trains.
16	933	12,915	38,585	64,309
20	986	12,221	36,663	60,852
23·25	1,042	11,564	34,549	57,581
60	1,050	11,476	34,285	57,143

Coal carrying capacity of wagon.	Weight of coal in a train.	Average number of 1,400-ton trains loaded daily to move the total Indian coal output for a working year of 300 days.		
		1910. Tons. 12,050,000.	1930. Tons. 36,000,000	1950. Tons. 60,000,000
Tons.	Tons.	Trains.	Trains.	Trains.
16·0	933	43·05	128·62	214·36
20·0	986	40·74	122·21	202·84
23·25	1,042	38·55	115·16	191·94
60·0	1,050	38·25	114·28	190·48

The foregoing figures accentuate the high state of efficiency to which Indian broad-gauge

coal-carrying wagons have been brought, and how closely they approach the practice of American railways which deal with about thirty-one times as much coal annually as that of the present Indian yearly output.

At first sight, therefore, it would appear that there is not much room for improvement in Indian railway coal traffic arrangements, or much prospect of reducing the cost of haulage, and therefore of freight rates.

The use of 60-ton bogie instead of 23¼-ton four-wheeled coal wagons would, however, secure the following improved duty :—

(*a*) Reduction in the number of vehicles to be handled at collieries, in marshalling yards, at receiving stations and in wagon-repairing shops.

(*b*) Reduction in the siding accommodation necessary for stabling trains and vehicles; and

(*c*) Saving in dead weight hauled.

It has been shown above that 17·5–60-ton bogie wagons will carry the same weight of coal as 45–23¼-ton four-wheeled wagons, a reduction of over 61 per cent. in number; labour in coupling, uncoupling, and handling vehicles being reduced by the same amount.

The over-all length of a 1,400-ton train, composed of 45–23¼-ton four-wheeled wagons (22 ft. 3 in. per vehicle), is 1,012 ft., compared with 790 ft. for 17·5–60-ton bogie wagons (45 ft. each), a saving in train length of 32 per cent.

The dead weight of a 1,400-ton train of 45–23¼-ton wagons (8·75 tons per wagon) amounts to 394 tons.

The dead weight of a 1,400-ton train of 17·5–60-ton wagons (20 tons per wagon) is 350 tons.

For a round trip of 500 miles (half loaded and half empty) the dead weight ton mileage for the two trains compares thus :—

45–23¼-ton wagons = 197,000-ton miles.
17·5–60 „ „ = 175,000 „ „

showing a saving in favour of the bogie wagons of 22,000-ton miles per round trip, or over 11 per cent., representing by the year 1950 a reduction in locomotive fuel consumption of 56,123 tons, and a saving in expenditure (at Rs. 10 per ton) of £35,000 per annum.

Notwithstanding the excellent duty performed by the latest type of India broad-gauge railway four-wheeled wagons, it will thus be seen that there are possibilities of improvements amounting to 61 per cent. reduction in the number of vehicles to be handled; 32 per cent. reduction in shortening of train length; and 11 per cent. reduction in the dead weight hauled.

The extent to which these opportunities are made use of, and a further reduction in already cheap freight rates rendered possible, greatly depends on the action taken at the present time, when such large numbers of wagons (which should be giving efficient service thirty years hence) are required to overtake the arrears of the past four and a half years, and so meet the requirements of present and prospective increased coal traffic.

The principal dimensions, weights, etc., of present standard flat-bottom coal wagons on Indian (5 ft. 6 in.), South African (3 ft. 6 in.), and United States (4 ft. 8½ in.) gauge railways, are compared below, and it will be noted that the weights carried per axle and per foot of wagon length are practically the same on the South African as on Indian railways, notwithstanding that the gauge of the latter is 2 ft. wider.

Detail.	Indian railways.	South African railways.	United States railways.
	Tons.	Tons.	Tons.
Coal-carrying capacity	23¼	45	60
	ft. in.	ft. in.	ft. in.
Length over buffers	22 3	40 3	45 0
Height over-all	9 0½	9 4½	10 0
Width over-all	10 0	8 7½	10 0
	cubic ft.	cubic ft.	cubic ft.
Cubic capacity*	980	1,890	2,520
Cubic feet per ton of coal-carrying capacity	42	42	42
	Tons.	Tons.	Tons.
Dead weight of wagon	8·75	17·00	20·00
Weight of coal	23·25	45·00	60·00
Gross weight of wagon	32·00	62·00	80·00
Do. per axle	16·00	15·50	20·00
Do. per foot of wagon length	1·44	1·44	1·77

Note.—An important detail in Indian broad-gauge railway wagon construction in which improvement is still possible is *wheels*. The standard wheel under the heaviest wagon axle loads (23 tons) on the railways of the United States of America is 33 in. diameter, compared with 43 in. for Indian broad-gauge wagons. Four pairs of 33-in. diameter wheels weigh about 1 ton less than the same number of

* Includes for piled load at 1 ton per sq. ft. of wagon-body top area.

43-in. wheels, and by that amount the *paying load* of an 8-wheel bogie wagon might be permanently increased; moreover, large wheels impose much greater stresses on axles for a given load, and for weights exceeding 15 tons these stresses may result in over-strained and consequently bent axles.

Probably this fact more than any other influenced American engineers in deciding upon a 33-in. diameter wheel for all goods vehicles on the railways of the United States.

FIG. 6.

An illustration of the 45-ton wagon is shown in Fig. 6.

The 60-ton wagons are similar in design to that shown in Fig. 6, but of greater capacity and strength.

What has been said with regard to coal applies equally to mineral traffic, the axle and bridge loads for which cannot greatly exceed those permitted for coal traffic.

The subject has necessarily been dealt with on very broad lines, but, in conclusion, the author hopes that the lessons of the past will be remembered, and that what has been said may suffice to mark the necessity for the provision at this time of rolling-stock of such a character as will ensure the maximum of efficiency from what is practically possible.

DISCUSSION.

THE CHAIRMAN (Sir Charles Armstrong), in opening the discussion, said the figures, percentages and comparisons Mr. Kelway-Bamber had given in his instructive paper were most useful, and would be highly appreciated by those who were specially interested in this important question. The development of the mineral resources of India was an important matter at the present time, when the question of industrial expansion was very much to the fore. Coal was the principal mineral in India, and until hydro-electric power could be increased would continue to be the chief factor in industrial expansion. Over 95 per cent. of the coal used in India came from the districts of Bengal, Bihar and Orissa. There were also, as Mr. Kelway-Bamber had said, mines in the Central Provinces, Hyderabad and elsewhere, and at the present time a boring was being made at Bhusawal, in Western India. That experiment had become necessary as the railways serving Bombay had to draw their supplies of coal mainly from Bengal, and, as the distance was considerable, the cost of haulage was a serious matter. The carriage of such a large quantity of coal across India required great numbers of

railway wagons, and owing to that fact the general trade of the country was frequently hampered. Several times during the past two years the booking of ordinary goods traffic had had to be curtailed owing to shortage of wagons and pressure on the lines due to the necessity of bringing coal across India to Bombay, largely for oversea consumption in connection with the war, but also for the railways in Western India, and for the mills in Bombay and elsewhere. He would like to point out that the railways in India were the lines of communication with their base for our armies in Mesopotamia, East Africa, Egypt and Palestine; the war traffic carried over the railways serving the various ports had been very large. This traffic was worked under exceptional difficulties, due to depleted staffs and the impossibility of securing needful supplies from home. It was found necessary in many cases to supplement those shortcomings with supplies obtainable in India, and although that, no doubt, had given an impetus to Indian industries, at the same time it was work undertaken under very great difficulties and under the pressure of a world-wide war. To those who had worked this heavy traffic very hearty acknowledgments were due; for it was owing in a great measure to their steady continuous work that the Empire was eventually victorious in the battles she was fighting in Mesopotamia and elsewhere. All grades of workers on the Indian railways made it a point of honour and patriotism to see that the Empire was not let down by any want of effort on their part, and the result was a brilliant victory in the Eastern theatres of the war. But the Indian railways had done more than the mere transport of troops, coal and supplies, for they manufactured in their workshops large quantities of shells, pontoons for bridging rivers, and many other things. They equipped hospitals and hospital trains, and fitted up steamers for the transport of horses and mules. Locomotives had been overhauled and fitted for service in Mesopotamia and East Africa, and immense supplies had been taken, not only from the stores of Indian railways, but from their working equipment and rolling-stock. The railways had therefore helped in a double sense. He thought he was justified in saying that without India we should have fared badly, and that with her help we had won the war. There was very little doubt that a much larger quantity of coal could be produced in India if labour was more plentiful. It was thought that the increase might be 40 to 50 per cent. of the present output, but Indian labour was irregular in its habits, and during the monsoon months the men often returned to their villages to cultivate their fields. It was very necessary, therefore, that efforts should be made wherever possible to give them land near to the collieries where they could make a permanent home. People often talked of the great surplus of labour in India; in reality there was very frequently a shortage, so much so that, unless stocks were held in reserve, the position sometimes became very difficult. In the Bengal districts the daily wage per head was only about 7½ annas, and in the report of the Indian Industrial Commission it was stated that the supply of labour was at present insufficient and intermittent, and was liable to be seriously affected by a good harvest or by an outbreak of an epidemic disease, to some forms of which the coalfields had in the past been liable. The Commission, however, recognising the great importance of the coal industry to India, had recommended a special survey of the coal position throughout the country, and if that was done it might lead to more mines being opened up, and to an improved system of railway connections, labour and organisation generally—all very necessary improvements. A few figures showing how greatly the railway traffic had increased might be of interest. Before the war Indian coal required in Bombay was brought round from Calcutta by sea. In 1913 the amount of coal received in Bombay by sea was 1,160,000 tons, of which over half came from Calcutta. In that year only 96,000 tons were received in Bombay by rail. In 1917 the shipments were only 22,000 tons, none of which came from Calcutta, whereas nearly 2½ million tons were obtained by rail. On the Great Indian Peninsula Railway alone the actual traffic for consumers other than the railway increased from 810,000 tons in 1914, to 1,822,000 tons in 1918. The railway requirements during the same period increased from 982,000 to just over 1½ million tons. Coal, as a matter of fact, on that railway now gave the highest receipts of any commodity carried. That was not exactly as it should be, but under the circumstances it was unavoidable, and the great problem was how could that question of coal haulage be reduced? Bombay was at a disadvantage by being so far away from the coalfields, but that disability had been largely reduced in recent years by the generation of hydro-electric power on the Western Ghauts, which had been largely availed of by the cotton-mills of Bombay, and a further curtailment in the demand for coal by the Bombay mill industry might be expected when the Andhra Valley installation was available. But they were bound to recognise that hydro-electric power had many limitations. Now that the war was over and regular supplies could, he presumed, shortly be expected from the Anglo-Persian oil-field, there ought to be a very considerable extension of the use of oil fuel by the railways of Western India. Although the cost might not differ very much from that of coal, there was very little doubt that the railways of Western India would do all in their power to encourage the use of oil fuel on their lines, as it would help to reduce the haulage of large supplies of coal from Bengal. Another important mineral in India was manganese, the output of which had rapidly increased in recent years, though quite lately, owing to the war and to difficulties in connection with freight, the output had fallen. There was a great future for the

manganese trade of India, and if a larger quantity could be used in India itself it would be a very good thing. At present manganese was mainly exported in a raw state to other countries, although the two existing iron and steel companies in India had, since the war, manufactured considerable quantities of ferro-manganese. The manganese mines were mainly in the Central Provinces, and to a smaller extent in Chota Nagpur, Bombay, Madras and elsewhere. That was another mineral which required a large number of railway wagons, and there had been great pressure at times to bring supplies to the ports for shipment. It was also a mineral that must be carried cheaply, as the competition of other countries had to be faced. As India produced, or could produce, a large variety of minerals, there was undoubtedly a great opportunity for the successful employment of capital. Unfortunately, although iron ore was found in many parts of India, it was not always in proximity to satisfactory coal supplies, and that made the question of expansion rather a difficult one. Coal also was very unevenly distributed, and it was generally poor in quality. But progress in many directions was being made, and after our recent experience of German penetration we should no doubt hold on to, and rapidly develop, our own resources.

Mr. L. R. W. Forrest said that Mr. Kelway-Bamber, in his able and lucid paper, had not referred to labour on the coalfields. Some years ago he (the speaker) was informed by a Calcutta man that 25 per cent. more output could be obtained from the coalfields if labour was available. The question of increasing the capacity of rolling-stock must be settled by the very capable consulting engineers of the various Indian railways. The chairman of the railway with which he was connected recognised the advantage of the use of larger and better wagons, but up to the present there had been no opportunity of carrying that desire into effect. The scarcity of rolling-stock was so great that it was determined to order wagons of the present standards and get them out as quickly as possible to India. He hoped the time would soon come, however, when engineers and manufacturers would be able to devote themselves more to the construction of larger wagons, which would be of great assistance.

Mr. Bhupendranath Basu, Member of the Council of India, in moving a vote of thanks to the author of the paper, said he had often grumbled at the short number of wagons which the railway companies had only been able to supply, because, as a shareholder or as a proprietor of coal concerns in India, he felt that his dividends might have been much larger if the supply of wagons had been greater. It was not Indians alone who were ignorant of the value of coal, for he believed the same remark applied to English people until very lately. In 1793, when Lord Cornwallis, the then Governor-General of India, effected the Permanent Settlement in Bengal, Bihar and Orissa, he gave away the whole of the mineral wealth of that rich province to men most of whom were formerly only collectors of rent. At that time nothing was known of the mineral resources of the province, and the successors of those men had now the entire mineral resources of Bengal, Bihar and Orissa at their disposal without having done anything to earn them. If the Government of India had the least control over those immense resources to-day, the story of India's prosperity would be different. But it was no use lamenting the past. Indians were beginning to realise, under Western influences, the great value of that buried wealth. The fabled wealth of India was referred to in many ancient and mediæval writings, but that fabled wealth was nothing compared to what was now being revealed. He almost felt that coal was the "open sesame" of India's wealth, that it was the key which would lead Indians to a position of really great wealth and prosperity amongst the nations of the world. They looked forward with great hope to the future of the coal industry, in the development of which many of his countrymen had taken a large and leading part. They were not only holders of shares in coal companies, but many of them had started coal concerns themselves and were running them with great success. Generally the coal industry, especially in the province that he came from, Bengal, was in a flourishing condition, and more might be done if the carrying capacity of the railways was increased, if facilities for obtaining wagons were greater, if the coal could be transported much more speedily than was now the case to the great centres of distribution. The Chairman had referred to the labour question, a very difficult problem in India. When one heard of the teeming millions of India, of its 300 millions of people, large masses of whom were on the verge of extreme poverty, it might be a revelation to people to learn that labour was so difficult to obtain for the great industries that were arising in that country. But the causes were not far to seek. Indians had been brought up under an ideal which was not that of wealth or material prosperity. They were attached to their homes and to their lands which had come down to them from generations. It was very difficult to induce an agricultural labourer to give up his ancestral home, or his ancient holding, and go and settle in a new place; the organisation of Indian industries did not afford sufficient facilities for the reproduction of the home life to which he was accustomed. Much as he (Mr. Basu) valued the industrial prosperity of Western nations, he should be sorry, as an Indian, to find the conditions of English industrial centres reproduced amongst the labouring population in the industrial centres of India. He might have read the story of industrial life wrongly; he might be accused of partiality to the ideals under which he had been brought up, but, nevertheless, he believed that the essential features

of Indian life should, as far as possible, be maintained, and in attracting labour to industrial concerns that truth would have to be borne in mind. Furthermore, labour in India was not at all organised on the same lines as in England. The war had brought immense wealth to the cotton trade, the jute trade, the steel trade, and various other trades in India; but when influenza came to India it swept off a much greater percentage of the population than anywhere else on the face of the globe, because the poor labourer was underpaid, ill-clothed, and underfed. Labour in India must realise its importance to Indian industries, and should be placed on a footing where its life could be lived on a higher plane than was possible at present. Once that was done, there would probably be less difficulty in the solution of the labour problem than was the case to-day. With regard to the future coal consumption of India, if facilities were provided for the haulage of coal there was a large field for its employment which yet remained untapped. Owing to the Permanent Settlement in Bengal, the fuel difficulty, especially amongst the poor, in spite of India being known as a wooded country, was a real one, for the trees did not belong to them, and they could not cut them without the permission of the owner of the soil. The poor were, therefore, driven for their fuel to the use of cow-dung, because coal was so difficult to get and so high priced, thereby depriving the soil of a very rich manure which it sadly needed, and they were also denied comforts which would be enjoyed if more fuel was available. With respect to the lower consumption of coal in India than in other countries, happily the people of India did not stand in very great need of fuel; they had not the same cold to fight against that English people had; they did not require much fuel for keeping themselves or their homes warm; and their days and nights had not the same curious habit of lengthening and shortening by curves; they were more or less regular in their duration, and, he was happy to say, not so uncomfortable. Therefore the fuel consumption in India was necessarily lower than was the case in colder latitudes. But in spite of that, if railway freights were easier, the consumption would be much greater.

COLONEL C. E. YATE, M.P., C.S.I., C.M.G., in seconding the motion, said he had listened with much pleasure to the last speaker's remarks on the iniquity of the Permanent Settlement of Bengal, and he hoped that Mr. Basu, in the important position he now occupied as a Member of the India Council, would do his utmost to equalise the burden in the way of taxation to be borne by Bengal in future with the burden now borne by all the other provinces of India. He hoped Mr. Basu would also see to it that, in the coming constitutional reforms, labour in India was given the representation it deserved on the councils, and that that representation was not solely confined to what was called the *intelligentsia*, especially lawyers and men of that class. He thought the paper had shown how utterly India was behindhand in railway progress. The fact that India, with a 5 ft. 6 in. gauge railway, could not do more than South Africa with a 3 ft. 6 in. gauge railway, would, he hoped, more than anything else, bring home to the Government of India the necessity for progress in its railway administration. It had been stated that by the time coal reached Bombay, owing to the cost of carriage its original price had gone up by five or six times. He was, therefore, pleased to hear the hope expressed that the railways in Western India would one day be run by means of oil. Oil refuse was largely used on the Trans-Caspian Railway. He pointed out how this oil refuse was brought across the Caspian Sea from Baku to Krasnovodsk, and used throughout the entire length of the Trans-Caspian Railway, and he could not see why the same oil refuse could not be brought down the Persian Gulf from the refineries at Abadan, near Muhamrah, to Karachi and Bombay, and used on the railways there in a similar manner. He looked upon that as one of the most urgent reforms that could be brought about in connection with railway administration in Western India.

MR. C. H. B. BURLTON, in supporting the motion, thought the fact that there had been considerable difficulty experienced in getting coal to places which were some distance from the pit's mouth was not due to shortage of coal so much as shortage of wagons in which to convey it. It would be of great interest if statistics could be published of the wagons at present available, and also the wagons necessary to convey all the coal that was required. From the figures given it appeared that 11 per cent. of the output was exported from India, and in view of the fact that coal was so much required in India that policy seemed to be open to criticism. He had on a previous occasion suggested that the Neilgherry Railway, which, since it was built twenty-five years ago, had been worked by steam power, should be worked by hydro-electricity obtained from the Katéri Falls. Sir Murray Hammick had pointed out that those Falls were already harnessed for the development of electricity for the Neilgherry Cordite Factory, but the Pykara Falls were still available for the purpose, and if they were harnessed there was a large scope for the employment of hydro-electric power. The same remark applied to many other parts of India where mountain railways existed, and the matter should receive early consideration, because he was convinced the time would come when India would require her full output of coal for her own use, and then hydro-electricity would become a necessary supplement. In addition, the sooner the power of all high masonry dams was brought into industrial use by developing hydro-electricity the better it would be for the prosperity of India and the Empire at large.

OBITUARY.

Alfred Hewlett.—The Society has lost one of its oldest Fellows by the death of Mr. Alfred Hewlett, which took place on September 14th last, at his residence, Hasely Manor, Warwick, at the age of eighty-eight. He joined the Society in 1863.

Mr. Hewlett was for many years a very prominent figure in connection with the mining industry of this country. At one time he was managing director of the Wigan Coal and Iron Company, Limited, and chairman of the Coshall Colliery Company, Limited, of Nottingham, and of the Ammanford Colliery Company, Limited, South Wales. He was also at one time president of the Lancashire and Cheshire Coal Owners' Association, and of the Mining Association of Great Britain, and he served on the Royal Commission on Labour in 1892. For twenty-six years he was chairman of the Northern Employers' Mutual Indemnity Company, and until a few years ago chairman of the Coal Conciliation Board for the federated districts. He was, in addition, president of the Lancashire and Cheshire Miners' Permanent Relief Society. He was deeply interested in educational questions and took an important part in the establishment of the Wigan Mining and Technical College.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m. :—

February 5.—Edward Carstensen de Segundo, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes." Lord Lamington, G.C.M.G., G.C.I.E., will preside.

February 12.—Sir Frank Heath, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

February 19.—John Francis Crowley, D.Sc., M.I.E.E., "The Use of Electricity in Agriculture in Germany." Sir John F. C. Snell, M.Inst.C.E., will preside.

February 26.—W. L. Hichens (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry." W. A. Appleton, C.B.E., Secretary, General Federation of Trade Unions, will preside.

March 5.—B. D. Porritt, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present." Professor Wyndham R. Dunstan, C.M.G., F.R.S., Director of the Imperial Institute, will preside.

March 12.—Walter Leonard Lorkin, A.M.I.E.E., "Electric Welding and its Applications."

March 19.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

March 26.—Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Design in Japanese Art."

April 2.—W. Norman Boase, "Flax."

Indian Section.

Thursday afternoons, at 4.30 p.m. :—

March 13.—D. T. Chadwick, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission."

April 3.—Brigadier-General Lord Montagu of Beaulieu, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

Colonial Section.

Tuesday afternoons, at 4.30 p.m. :—

February 25.—Edward J. Duveen, Fellow of the Royal Statistical Society, "Key Industries." W. A. S. Hewins, M.A., late Under-Secretary of State for the Colonies, will preside.

March 4.—Professor John Cunningham McLennan, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

May 27.—Sir Edward Davson, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Cantor Lectures.

Monday afternoons, at 4.30 p.m.

J. A. Fleming, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

Syllabus.

Lecture I.—February 10.—Electromagnetic waves—Æther theories: Maxwell's electromagnetic theory of light—Hertzian waves—Aerials and radiators in modern wireless telegraphy—Methods of creating damped and undamped waves for radiotelegraphy.

LECTURE II.—FEBRUARY 17.—The transmission of long electromagnetic waves over sea and land—Penetration of high-frequency currents into conductors—The attenuation of radiotelegraphic waves—Diffraction of such waves round the earth—Effects of the atmosphere—Long-distance stations.

LECTURE III.—FEBRUARY 24.—The detection of electromagnetic waves — Magnetic, electrolytic, thermionic, and crystal detectors — Receiving arrangements—The development of the thermionic detector—The Fleming valve—The three-electrode valve in radiotelegraphy and radiotelephony.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEBRUARY 3...Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. H. J. R. Marston, "The Philosophy of Bishop Butler."

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Presidential Address by Mr. W. N. Twelvetrees, "The Development of British Concrete Shipbuilding."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. 1. Dr. J. C. Philip, "The Physical Principles underlying Refractometry." 2. "British-made Refractometers": (a) Mr. F. Stanley, "Improved Abbe and dipping Refractometers"; (b) Messrs. F. Twyman and F. Simeon, "Accuracy Control in the manufacture of Abbe and Pulfrich Refractometers." 3. "Applications of the Refractometer to Technical Analysis": (a) Mr. H. Main, "The Refractometer in the Sugar Industry"; (b) Mr. A. E. Berry, "The use of the Refractometer in the Examination of Chlorhydrin"; (c) Miss A. Homer, "The use of the Refractometer in the determination of the protein content of Sera"; (d) Messrs. E. R. Bolton and C. Revis, "Note on the application of the Refractometer to the analysis of Oils and Fats."

TUESDAY, FEBRUARY 4...Rontgen Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8.15 p.m. 1. Dr. F. Hernaman-Johnson, "Protection in Diagnostic Work: a Consideration of the Effects of Scattered Rays and Secondary Rays." 2. Dr. W. Makower, "A Langmuir Exhaust Pump."

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. T. M. Morris, "Study of Electric Arcs and their Applications." (Lecture I.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Professor F. Haverfield, "Roman Caerwent."

Zoological Society, Regent's-park, N.W., 5 p.m. 1. Sir D. Mawson, "Australasian, Antarctic, and Subantarctic Life.' 2. Mr. R. I. Pocock, "On the External Characters of the Existing Chevrotains."

Colonial Institute, Central Hall, Westminster, S.W., 4 p.m. Mr. V. Lloyd-Owen, "The Peace River District (Canada): its Resources and Opportunities."

British Women's Patriotic League, South Lodge, Rutland-gate, S.W., 3 p.m. Sir Herbert Thirkwell White, "Burma."

WEDNESDAY, FEBRUARY 5...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. E. C. de Segundo, "The Removal of the Residual Fibres from Cotton Seed and their value for Non-Textile Purposes."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. G. D. Leechman, "Efficient Inventions—with special reference to Patents affected by the War."

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Annual General Meeting. 2. Mr. D. Pullman, "Recovery of Nessler Reagent." 3. Mr. John Allan, "Technique of Iodine Determinations: with a note on a new machine for sub-dividing oleaginous seeds."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Mr. W. Buckley, "Practical Steps that should be taken to ensure a National Clean Milk Supply."

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, E.C., 4.30 p.m. Mr. E. J. P. Benn, "The Industrial Awakening."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. A. Vallance, "Building Materials and Local Conditions."

THURSDAY, FEBRUARY 6...Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. N. E. Brown, (a) "Old and New Species of *Mesembryanthemum*, with critical remarks"; (b) "A New Species of *Lobostemon* in the Linnean herbarium." 2. Dr. J. R. Leeson, "Exhibition of Mycetozoa from Epping Forest."

Chemical Society, Burlington House, W., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. W. Wilson, "The Movement of the Sun, Earth, and Moon." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Lantern Lecture on "Some Common Objects of the Microscope."

FRIDAY, FEBRUARY 7...Poetry Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m.

Royal Institution, Albemarle-street, W., 5.30 p.m. Professor J. G. Adami, "Medical Research in its Relationship to the War."

Philological Society, University College, W.C., 8 p.m. Professor E. Weekley, "Some Etymologies."

SATURDAY, FEBRUARY 8...Ruskin Centenary Council, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Professor J. W. Mackail, "Ruskin."

Royal Institution, Albemarle-street, W., 3 p.m. Professor H. P. Allen, "The Works of J. S. Bach. Lecture II.—The Overture."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—January 31, 1919.

No. 3455. FEBRUARY 7, 1919. Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2.

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,455. VOL. LXVII.

FRIDAY, FEBRUARY 7, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 10th, at 4.30 p.m. (Cantor Lecture.) J. A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." (Lecture I.)

WEDNESDAY, FEBRUARY 12th, at 4.30 p.m. (Ordinary Meeting.) SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research." The Most Hon. the MARQUESS OF CREWE, K.G., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

EIGHTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 5th, 1919; LORD LAMINGTON, G.C.M.G., G.C.I.E., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Burford, H. G., London.
Day, Bernard I., Derby.
Evans, Daniel, Swansea.
Evans, Edward Victor, F.I.C., London.
Eyre, Vice-Admiral Francis G., R.N., London.
Lewis, Robert Thomas, B.A., London.
Perry, John J. Benedict, London.
Phillips, Hon. Nelson, Austin, U.S.A.
Pomeroy, Laurence Henry, London.
Rowbotham, William Johnson, South Croydon, Surrey.
Stewart, Patrick Archibald, Bombay, India.
Walton, Eric Bell, Edmonton, N.
Wood, William, F.R.Hist.S., Polperro, Cornwall.
Younger, John, Washington, D.C., U.S.A.

The following candidates were balloted for and duly elected Fellows of the Society:—

Alam, Sahebzada Md. Habeeb, Calcutta, India.
Dilke, Pearl, Lady, Brighton.
Edwards, H. J., Elyria, Ohio, U.S.A.
Spicer, A. Dykes, London.

A paper on "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-textile Purposes" was read by EDWARD CARSTENSEN DE SEGUNDO, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

SIXTH ORDINARY MEETING.

Wednesday afternoon, January 22nd, 1919; SIR WILLIAM NAPIER SHAW, Sc.D., F.R.S., Meteorological Adviser to the Government, in the chair.

THE CHAIRMAN, in introducing the author of the paper, said Colonel Lyons had been Director-General of the Survey Department in Egypt, in which capacity he had established a very efficient Meteorological Service for that country. After returning to England he became one of the representatives of the Royal Society upon the Meteorological Committee, which was the Government Committee responsible for the grant of the Meteorological Office, and was then lent by the War Office to the Meteorological Office, with particular reference to the Mediterranean, in the early stages of the war; he had since then taken over the administration of the work of the Meteorological Office when the whole work of that Office became too much for one person to do. Colonel Lyons, therefore, was fully acquainted with meteorology and its administration from many sides.

The paper read was—

METEOROLOGY DURING AND AFTER THE WAR.

By COLONEL H. G. LYONS, D.Sc., F.R.S.,
Acting Director of the Meteorological Office.

During the past four years and a half of hostilities meteorology has, like many other branches of knowledge, been utilised in naval

and military operations to a far greater extent than ever before. On land, at sea, and in the air, its applications have been widely increased, and thousands have been daily brought into contact with this class of information for whom it has gained a new and a wider importance. In offensive operations, in the utilisation of transport, in reconnaissance on land or in the air, the weather is always a factor of primary importance, and as soon as those responsible for such operations realised the reliability which could practically be attained in meteorological forecasting, the latest and most detailed reports were naturally demanded, and were regularly utilised. Consequently, there are now a large number of officers in the Services who have had practical experience of the value of meteorological information when it has been prepared from sufficient data, and by men who have been thoroughly trained in the subject. It is, therefore, highly desirable that full advantage should be taken of the experience which has been gained during the war in order to meet, as adequately as possible, those demands which will be made upon meteorology in the general reconstruction which is now beginning.

In some ways the conditions which prevailed during hostilities were favourable to advances in the subject: special facilities were given for the rapid transmission of reports, kite balloons could furnish series of observations at various heights, aeroplanes were available to observe the temperature in successive layers of the atmosphere up to 12,000 or 14,000 feet; the velocity and direction of air currents up to 25,000 feet and more were determined by the bursting of shells fired at high angles; pilot balloons at perhaps a hundred stations were observed four or more times daily. In these and other ways a vast store of information has been amassed, which has already been utilised, but which remains available for much more detailed study in the immediate future; and not the least difficult problem will be to reduce the mass of information to a manageable and orderly arrangement.

In order to appreciate the great development in the practical application of meteorology which has taken place during the past four years, it will be necessary to review briefly the meteorological organisations which existed at the beginning of 1914 in the United Kingdom.

There were then in this country the State Meteorological Service (the Meteorological Office) and a Naval Meteorological Service, which had been formed in 1913 to meet the needs of the Royal Naval Air Service. Besides these a private organisation, the British Rainfall Organisation, collected and discussed observations of the rainfall of the British Isles, and studied all questions connected with rainfall; also two scientific societies—the Royal Meteorological Society and the Scottish Meteorological Society—specially devoted themselves to the advancement of meteorological science. It will be seen, therefore, that only the State Service could provide a career for anyone desiring to take up meteorology as a profession, and, as the staff of this Service was comparatively small, it is hardly surprising that the great majority of meteorologists were amateurs in the sense that they studied the subject from their interest in it, outside their ordinary occupations.

With so restricted a demand for trained meteorologists we can hardly wonder that colleges and universities did not provide instruction in the more advanced branches of the subject, which was represented educationally by the elementary climatology taught in connection with geography, or by a few references to the subject in courses of physics.

In the Meteorological Office the policy for some years had been to bring in men who had had a thorough scientific education at a university and to encourage them to devote it to the study of the many problems which meteorology had to offer. This was a great advance from the empirical treatment of the subject, and has been amply justified by the success obtained when this policy has been tested under the conditions of active service. But although this development was in progress the meteorologists with scientific training were few, and besides any demands which might be made by the Services the work of the central office had to be maintained, not only at its peace time output, but at a much higher standard.

For the general public current meteorology was mainly represented by the daily forecasts and the weather summaries which appeared in the press, and the cases in which these failed to describe accurately the weather in the reader's immediate locality usually impressed him more than their general accuracy as tersely worded descriptions of conditions which were likely to prevail over an extended area, such as South-Eastern England. The percentage of accuracy of these daily forecasts, when systematically analysed, has been high, but that may not have been, and probably was not, the impression left on the minds of newspaper readers who from time to time referred to these

forecasts. They also would not appreciate that the forecast which they were reading in their morning paper was prepared from observations taken at 6 p.m. the day before, and could take no account of changes which then showed no indications of their approach. Such changes are often propagated with great rapidity, and for those which reach us from the westward our western observatories on the shores of the Atlantic, or even wireless reports from ships, give but a short period of warning in many cases.

This is mentioned not so much to emphasise the difficulties which surround the subject of accurate forecasting as to enable us to appreciate the point of view of those who had only been brought into contact with meteorology in this superficial way, but who, on the outbreak of hostilities, soon found that the weather affected their preparations and their operations at every turn. It was hardly to be expected under these circumstances that all Staff officers should at once realise what information trained meteorologists could provide, or to what extent their reports and warnings could be relied upon in practice.

But besides what may be called the routine work of a meteorological service, the issue of forecasts and warnings, the preparations of climatological summaries of different regions, and the discussion and publication of meteorological observations, a large amount of systematic research had been carried on for many years in this country and also in co-operation with the meteorologists of other countries.

In the course of the last two decades investigations have been extended from the surface of the earth into the air by means of kites and balloons, and our knowledge of the conditions prevailing up to ten and even fifteen miles above the earth's surface has thereby been steadily increased. Self-recording instruments continuously registering the pressure, temperature and humidity, have been carried up through the lower seven miles (11 kilometres), the troposphere—the region in which the temperature falls with increasing height—and far into the stratosphere above it, sometimes to heights of 12½ miles (20 kilometres) or more. In this way the remarkable fact of the differentiation of the atmosphere into the lower troposphere and the overlying stratosphere has been established, and further investigations indicate the great importance of these upper regions of the atmosphere in the solution of many problems relating to the weather.

Investigations of this character have been regularly carried on by the Meteorological Office for years past at South Farnborough, and at Pyrton Hill and Benson, Oxfordshire, by Mr. W. H. Dines, F.R.S., to whom so much of our knowledge of the upper air is due. Several private observers—Captain C. J. P. Cave, at Ditcham Park, Petersfield; Professor Petavel, of Manchester University, at Glossop Moor; Captain Ley, and others, have also materially contributed to the investigations of the upper air.

With the gradual introduction of aircraft into the Army and the formation of the Royal Flying Corps, meteorological establishments were formed at South Farnborough in 1910, and at Upavon in 1913, where the study of the upper air was carried on regularly. In this way, and with the material furnished by the meteorologists of other countries, a very large amount of information had been collected, and, to a large extent, discussed and utilised before the outbreak of war, but this was for the most part known and appreciated only by those who were especially interested in the subject, and the bearing of the results obtained had not reached the wide circle of those who were later to become acquainted with them under the exacting conditions of active service

It is remarkable how little known the State Meteorological Service was at the outbreak of war even by those who required meteorological information. Inquiries went to scientific societies, to individuals interested in the subject, but few seemed to know that a Government establishment, with information accumulated during more than half a century, was available for preparing its material to meet any special need. Its secluded position over a post office in South Kensington, where only a copy of the Daily Weather Report indicates its headquarters to the passer-by, no doubt accounts for this in part; certainly very few of those who inquired of me about it during the war had any idea where it was or how it did its work.

Let us now consider the effect of the outbreak of hostilities upon the normal routine of meteorological work.

Some lines of work had to be abandoned, new ones had to be taken up at once; men would be required for any extension, while at the same time the needs of the Army demanded all who were able and willing to serve. Many of the staff of the State Service joined the Army in those early days who would have been very profitably employed in the meteorological units which were formed later or even in the office

itself, where the work became ever increasingly heavy, while the task of finding additional staff became constantly more difficult. The work of a meteorological office, where it is carried on day and night, is not light, and after months the strain becomes severe, overtaxing any who are not thoroughly fit and sound.

On the outbreak of war in August, 1914, meteorologists were at first considerably handicapped by the reduction of their supply of information. Wireless reports from ships ceased; weather telegrams from Germany and Austria were no longer available; and Central Europe became a blank on the working charts of the Meteorological Office. The censorship over all inward and outward telegrams disorganised the supply of meteorological information from allied and neutral countries for a while, but this was soon rectified, and daily weather reports could again be prepared though lacking part of the Continental information. As time went on the need for more and more distant stations was felt, and by 1916 reports were being regularly received from Spitzbergen to the North African Coast and Cairo, and from Iceland and the Azores to the Russian stations of Petrograd, Nicholaieff, Sebastopol, and Batum.

This provided a far more extensive daily weather map than in times of peace, from which it was possible to deduce, often with much accuracy, the weather conditions over Central Europe, and to supply reports of the general conditions and the direction in which they were likely to develop to the meteorological officers on the different fronts and to other offices and departments requiring the information.

The supply of daily weather reports and forecasts to the public was stopped, but their preparation was continued actively in the Meteorological Office, where the telegraphic reports which were collected several times daily reached the number of about one hundred, and the information which they contained was compiled on working charts from which the forecasts were prepared. These were issued to the Admiralty, to various dockyards, to the Grand Fleet, various battle squadrons, submarine flotillas, etc., each of which required reports and forecasts adapted to their special needs. Similar information was supplied to the Naval Meteorological Service for the Royal Naval Air Service, and to numerous units of the Royal Flying Corps, or the Royal Air Force as it afterwards became.

This was a very large increase on the normal work of forecasting in peace time, for different units required different information in their special work, and as new operations developed these requirements changed. The information which was supplied was such as seemed best adapted to the needs of the time and place, but the forecaster is often greatly handicapped by not knowing the purpose for which his information is to be used, and the recipient of the forecast usually does not know whether a more detailed report is obtainable. The whole question of supplying meteorological information to those who make use of it is a difficult one, for co-operation of both sides is essential, and a carefully planned organisation is necessary if the best results are to be obtained, for the best and most detailed reports are robbed of half their value if the recipient has not some knowledge of the subject.

The reports which contain the observations taken at 7 a.m. cannot be collected, discussed, and issued as forecasts much before 10 a.m., since Continental telegrams are often late in their arrival; there was therefore at the beginning of the war no fresh information available for aviators in the early morning or for use in preparing plans for the day's operations. It, therefore, became necessary to take observations in the early hours of the morning, and 3 a.m. was the hour chosen at first, but this was not found to be early enough, and 1 a.m. was finally adopted, making the observing hours 1 a.m., 7 a.m., 1 p.m., and 6 p.m. Thus a continuous twenty-four hour forecasting service was established and has been maintained in operation up to the present time to prepare forecasts and reports four times daily; the observations taken at these selected stations were telegraphed to the Meteorological Section at the British General Headquarters in France, and to other stations that required them, as well as to the Meteorological Service of the French Army and later to that of the American Expeditionary Force.

The daily weather report which is normally issued in peace time is a document which has grown up gradually and by successive changes. It has also been the rule to publish with the map the statistical material which has been used in its production, so that the reader can check its correctness and, if he pleases, draw his own deductions from it.

Under service conditions something simpler, plainer, and more direct in its presentation of the opinions of the trained meteorologist who prepared it, was needed. Those who had to make

use of the daily weather reports were usually far too busy to wish to study the statistical material before accepting the meteorological opinions which were offered to them. They wanted a direct statement of expert opinion of which they could make use in preparing their own plans of action. The desire for such expert assistance was also shown by many requests that forecasts should be expressed in "perfectly simple and non-technical language." To this very reasonable request it is not so easy to accede as it may seem. Such expressions as "a depression advancing from the westward," "a secondary depression developing over the Channel," "an anti-cyclone spreading northward," are more than mere statements of fact; they convey to all who are acquainted with meteorology much additional information depending on the weather conditions described, which it would take several paragraphs to describe simply and in non-technical language. The same is true of every technical subject; whether it be a branch of science, or of technology, or for that matter of any form of human activity. Everywhere technical terms come into use since they are convenient and economical; and they describe a certain set of conditions more precisely than can be done by any circumlocution. The only remedy is for those who require to make use of meteorology to make themselves acquainted with a few of its technical terms, just as a motorist does with those of motor engines, or a soldier with those of military organisation.

But so far as meteorological conditions could be described in plain language, this was done in a set of special daily weather reports which were issued in the early morning, before noon, and in the afternoon to all who required them; and these were supplemented by special summaries, one of which dealt with the prevailing and the prospective weather conditions on all fronts where military operations were in progress, and another with the weather conditions in the various sea areas round Europe.

In one of these special reports, that issued at 11 a.m., information about the direction and the velocity and direction of air currents at high altitudes, was specially included. A series of six small inset maps of the British Isles and North-Western France gave this information from a large number of stations at 1,000, 2,000, 3,000, 5,000, 10,000, and 15,000 feet whenever it was available. More stress was laid in it upon visibility, especially in areas of importance, and an inset map of the Thames estuary gave special information for the region eastward of London.

The whole of this information was of a highly confidential character, since Germany and Austria were cut off from all weather reports from meteorological stations to the westward, except those of neutral countries, Norway and Spain. In the majority of cases changes in weather conditions travel in an eastward direction, so that for forecasting purposes information from as far as possible to the westward is of the highest importance. The precautions that had to be taken necessitated the use of cypher codes and restricted the supply of meteorological information, since it was difficult to bring to the notice of all to whom it might be useful the amount and character of the meteorological information which could be supplied to those entitled to receive it.

We shall doubtless learn eventually to what extent the precautions taken sufficed to prevent information about the weather conditions over the British Isles and to the westward reaching the Central Empires, but at the time we had to depend mainly on negative evidence. It was not difficult to estimate from the working weather chart what sort of forecast the enemy meteorologists would probably make on the assumption that the information from a wide area to the westward of them was not available, and this was done daily as part of the routine of the Meteorological Office. In the case of attacks by enemy aircraft it was fair to assume that their meteorological service considered the conditions to be reasonably favourable; and this was compared with the estimate of their opinion which had been formed here. Occasionally enemy forecasts were available, and these were compared in the same way. Negative evidence is not conclusive, but the impression that we gained was that little, if any, meteorological information of value was obtained from our area.

Many cases could be cited where operations were undertaken by the enemy which it seemed very unlikely that he would have undertaken had he possessed the information which we had here. One, however, may be mentioned. On February 17th, 1915, the conditions over the British Isles were apparently considered favourable by the enemy meteorologists, for Zeppelins crossed the North Sea for the East Coast of Great Britain. Before midday, however, a deep and rapidly moving depression had appeared off the coast of Ireland and moved rapidly eastwards, overtaking the airships before they

could return, and wrecking two on the Danish coast.

By the spring of 1915 two branches of the Army, the Royal Flying Corps, and the Special Brigade, R.E. (Chemical Warfare), had decided that they required more detailed information about the weather and meteorological conditions than were furnished by general forecasts for the region in which they were operating, or by descriptive climatological summaries, however detailed. They required the co-operation of trained meteorologists who could explain the meaning and the limits of the forecasts, who could answer questions, or give advice, and who would arrange for fuller or more suitable information being furnished when required.

These demands for the provision of trained meteorologists in France led to the formation of a meteorological section as a unit of the Corps of Royal Engineers which had at first a strength of four officers and twenty non-commissioned officers, but the establishment was repeatedly increased until, when hostilities ceased, it consisted of thirty-two officers and about two hundred other ranks, and provided sections for duty, not only in France, but also on the Italian and Macedonian fronts, besides a reserve section at home. From a small unit at General Headquarters in France the organisation developed until there was a meteorological unit with each army and one with the Independent Force, R.A.F., these units having their groups of observers and pilot balloon stations reporting to them. The telegraphic weather reports from the stations in the British Isles, as well as those received from a large number of European stations, were at first thrice daily, and later four times daily, telegraphed from the Meteorological Office in London to the Meteorological Section at General Headquarters in France, in order that weather maps might be drawn and forecasts prepared there as might be required. This information was supplemented by data which the Meteorological Section collected from its stations on the British front, and also from other parts of France through the French Meteorological Services.

In this way on the Western Front, and similarly at later dates on the Italian and Macedonian fronts, a network of meteorological stations was built up, which, with the addition of the data and reports furnished by the Meteorological Office, enabled the meteorological officers to supply the information which the different Services required for their special purposes, to issue forecasts and weather warnings, and also, as will be seen later, to increase very materially the accuracy of the work of some of the Services.

Thus, under the new conditions of modern warfare the single State Service of pre-war days had been supplemented by a Naval Meteorological Service, which provided meteorological officers and *personnel* for the naval airship stations, and by an Army Service which furnished the meteorological staff in each area of military operations. Under this arrangement Staff officers, chiefs of technical services and others, were better able to utilise meteorological information and to obtain it in the form best adapted to their needs. Meteorological officers were also more in touch with the special requirements of the Services in their area, and becoming acquainted with the local conditions were enabled to revise or supplement general forecasts to meet the special case of their own area. This system of a central office, collecting all information by telegraph, telephone, or wireless telegraphy, and transmitting it to local centres where a trained meteorologist well acquainted with the conditions of his area is able to modify or develop it so as to furnish a more specialised forecast for that particular area, seems to be the most rapid and the most economical.

The task of providing the *personnel* for this military unit was no easy one for, as has been already mentioned, the staff of the Meteorological Office was small, and outside it there were very few expert meteorologists who were available. At first three of the senior staff of the Meteorological Office received commissions for duty in France, and afterwards a number of men who had had a thorough scientific education at a university joined the Meteorological Office for longer or shorter periods of training before being posted to the Meteorological Section, and in this way a high-grade scientific staff was formed and maintained. To a training which included especially mathematics and physics, was added as much instruction and practice in advanced meteorology as could be given in the time available, and on the basis of such an education the meteorological aspect of the problems was quickly appreciated.

As has been already pointed out, the proper and effectual employment of meteorology demands the co-operation of two parties, the meteorologist and those who require meteorological information and advice. Unless the meteorologist is told the end to attain which his co-operation is to be an aid, it is difficult for him to employ his information to the best advantage. In this war, the first in which

meteorology has been regularly used, the problem how the meteorologist could make himself most useful had to be solved by those who formed the first meteorological unit on the Western Front.

As time went on the scope and number of such reports and warnings steadily increased, until there was a regular and continuous flow of information sent out from meteorological offices to the General Staff and to various branches of the Service for them to utilise as best fitted the operations in hand. The Royal Air Force required forecasts of weather for short periods which they could use for their reconnoitring and bombing squadrons; for day operations reports of the wind direction and velocity obtained from pilot balloon ascents and high-angle shell-bursts were communicated from different altitudes up to 20,000 ft.; for night operations information for lower levels sufficed, and the arrangements had to be modified. For work at high altitudes a central station could supply information adequately, but when data concerning lower levels became important, where the air turbulence set up by friction with the earth's surface became a material factor, the reports were more effectively supplied by local stations where the special conditions could be more effectively studied. For all this the most rapid means of transmission is essential, for the shorter the forecast period, and the more detailed the forecast in its information, the more rapidly must it be placed at the disposal of the aviator if it is not to mislead him. These reports were largely supplemented by telephone inquiries by those interested, and a precision was demanded which was often very difficult and sometimes impossible to attain. Would the sky clear before midnight? Would there be fog at such and such a place some fifty or sixty miles away at 2 a.m.?—perfectly fair questions, but often difficult to answer. Success in answering them is reached by having as meteorological officers men who have an acquaintance with the physical character of the region, and who also possess such a scientific training that they instinctively proceed from cause to effect, and facts at once fall into their place in their minds. This is very different from the acquired skill of an empirical forecaster who can never attain the same confidence in his opinion. The work of a meteorological officer who has to advise on the suitability of conditions for long flights, especially on active service, is very responsible and throws a great strain on him since he cannot but feel that on his advice great risks may be taken and grave danger encountered. In regions where high plateaux exist near the seacoast, as in Macedonia, the cold air currents which stream downwards, by reason of their greater density, to lower levels often attain full gale velocity blowing in violent gusts, and constitute an element of serious danger to aviators. The conditions which favour such a phenomenon are known and recognisable, but it may be very difficult to say precisely whether or not the descent of cold air will take this violent form.

Sudden squalls and thunderstorms are matters of serious importance to aviators, and especially to such large objects as kite balloons. Special attention was therefore paid to conditions which favoured their occurrence. The information obtained from the usual weather reports from a network of stations was supplemented by temperatures at various altitudes which were observed from aeroplanes; high-level mountain observatories in Southern France furnished their reports; and in every way indications of instability in the atmosphere were watched for. Increased certainty was obtained later by reports from a screen of specially-selected stations to the north-westward, westward, and south-westward, who reported these disturbances as they travelled across the country.

In chemical warfare a different set of problems were encountered. Here we are concerned with the movement of air-currents close to the surface of the ground, affected by all its irregularities, diverted this way and that by obstacles, and generally in that state of irregular motion known as turbulence in which eddies form, break up, and reform, greatly complicating the conditions. At night, too, when the surface wind may die down to a calm and the ground cools under a clear sky, the colder and heavier air streams down from higher ridges into valleys and low ground. Consequently the direction and velocity of air currents along the front had to be constantly observed and studied in relation to the relief and conditions of each section; so long as the wind was favourable for enemy operations, or even likely to shift into a favourable quarter, observations, reports and warnings were unceasingly needed.

But, besides the aviators, there are other branches who are vitally interested in the conditions which prevail in the upper air. Projectiles leave the firing-point and traverse a considerable thickness of the atmosphere during their flight, reaching an altitude of about

10,000 ft. for a fifty-second trajectory. In its passage it passes through air masses of different temperatures and consequently of various densities, so that a correction has to be applied to the range tables. On a winter day, when the temperature at the surface is 3° F., the temperature at 3,000 ft., 6,000 ft., and 9,000 ft. may be 15° F., 16° F., and 12° F., so that any correction based on the temperature near the ground would be wrong. Also the wind varies considerably and often irregularly both in velocity and direction as the ground is left, so that a correction based on the conditions there will probably be widely different from that which should be used on any particular occasion. These corrections, when computed by the aid of meteorological determinations of velocity and direction throughout the air strata traversed by the projectile, have been found to improve the accuracy of the practice very materially, not only for large guns with a high muzzle velocity, but also for howitzers and trench mortars where the velocity is low but the angle of elevation is large.

These considerations led to a much wider application of meteorological information to the practical correction of gunnery than had hitherto been employed, and reports of upper air temperature and of the velocity and direction of the wind at various altitudes were regularly prepared and transmitted from meteorological stations along the various fronts. This increased application of meteorology to ballistics raises many problems of interest and importance, which demand for their solution the co-operation of scientific gunnery and meteorological science of the highest order.

To mention another field, the sound waves which are recorded in sound ranging, that wonderful adaptation of the physical instruments of the laboratory to practical use on the field of battle, traverse the lower layers of the atmosphere, and as higher and higher accuracy was aimed at it became clear that meteorological observations must be made concurrently, and utilised in order to attain the desired precision.

Besides such applications as these, summaries of the climate conditions prevailing on the various fronts where operations were being carried on were naturally demanded, but the mean values of the different meteorological factors which are used by the meteorologist in his comparisons and investigations are not the most suitable form in which to present the information for practical use. Here the amount of variation of, for instance, rainfall is of more importance than the mean value derived from a long series of years; the greatest and least amount that is likely to fall in any month or in a day; the number of occasions in any month or in a day; the number of occasions in any month that such and such an amount of rain is to be expected. In temperature, wind force, wind direction, the same sort of information is desirable, and in order to provide it a very large amount of manuscript record had to be reworked and recompiled. New questions of all kinds were asked.

Frequent mention has been made during the war of the meteorological efficiency of the enemy's organisation, and from the very favourable conditions which he experienced during many of his operations, his superiority in these directions was not infrequently assumed. It is not possible to compare the effectiveness and success of the rival organisations until much more information is available, and in the discussion and investigation of past operations the various contributing factors have been sorted out and duly weighed. No doubt Germany started with a much larger number of men who had received a scientific training in the subject, for professors of meteorology existed at several universities; the appreciation of the subject and its practical value too, may have been more general among that nation; but, as a personal opinion, I do not believe that they attained a higher standard than our own. Many apparently did not realise that the occurrence of bad weather during operations did not necessarily mean that the commander and his staff had no information regarding the impending weather changes. Very likely he had, but weather is only one of many factors which have to be taken into consideration, and it must often be that operations planned and prepared must be carried out whatever the weather may be, though a good forecast may at the last moment enable him to judge whether nearer or more distant objectives are likely to be attained. Forecasts extending over the many days which may be necessary to prepare an attack are not practicable in these latitudes and in the present state of our knowledge.

Free discussions and conjectures on the subject of the enemy's advantages and the necessity for guarding a strict silence regarding the details of our organisation naturally led many to doubt whether adequate steps had been taken to utilise meteorology to the full. Many offered their services as forecasters of experience, or as having methods which, they

considered, could give highly reliable results, but they did not realise that much more was needed than a brief description of general weather conditions. They did not know that a large and somewhat intricate organisation had been found necessary, in which each man played his appointed part, and from the combined results of whose labours the required information was evolved.

The foregoing outline of the directions in which meteorology was required to develop during the war may serve as an introduction to a forecast of the services it may render in the future under less restricted conditions.

Secrecy has been replaced by the publicity which was formerly enjoyed; lines of work which had to be laid aside can now be resumed; sooner or later information will be again obtainable from Central Europe. On the other hand, the controlling factor of expense which had relaxed its grip while hostilities lasted may again limit the developments which are desired. There are now four State meteorological services in operation—the Meteorological Office, the Admiralty Meteorological Service, the Meteorological Section, R.E., for the Army, and the Meteorological Service, R.A.F., of the Air Ministry—and when the relations and the means for co-operation between these four services come to be worked out, a number of considerations will have to be taken into account. The experience of the past four years has provided much food for reflection, for work has been carried out both on an extended scale and also by an extremely detailed study of conditions prevailing over a comparatively limited area. The British Isles and the surrounding seas furnish an example of the former class of work; the Western Front, with its very detailed service of reports and warnings, as well as its supply of information for special purposes, is an example of the second. Then from time to time there arose the question of advising for long-distance flights. These same classes of problems are still before us, and those meteorologists who are occupying themselves with weather have to consider the special problems of all these three classes. Larger regions are already dealt with by the Meteorological Services of different countries, but these will have to be reorganised so as to collect information more rapidly, to issue more frequent reports, and be prepared to supply information on more varied lines than in the past. They should also be active distributors of information, judging what is needed and offering it, and not merely storehouses of knowledge for those who need to come and ask for the information that they require. The detailed study of local conditions for the weather reports of a restricted area, based on the general forecasts and reports of a central office, will correspond to the first of these. Such secondary forecasting and weather stations would not be very numerous, but should have a highly competent scientific staff on whom other stations would depend for their advice and information.

The collection of meteorological information on various air routes is more difficult, since a new field of study is thus being opened up, but on many of them there is a large amount of material available if it is judiciously made use of. Unfortunately it is unequal in its distribution and in its quality, besides being very widely scattered, so that the task of extracting and compiling it will only furnish useful results if qualified meteorologists undertake the work.

So far as the study of the weather and the issue of forecasts is concerned, short-period meteorology as it may be called, rapidity of transmission of the observations to the Central Office where they are discussed and compared, and of the forecasts, warnings, etc., which are sent from it, is the first essential, and the needs of aviation have only accentuated this. Observations should be in the Central Office for the forecaster's use not later than one hour after they have been made if he is to get out his reports and warnings early enough to be of effective use to aviators. This will mean a considerable acceleration in the collection and transmission of reports from some parts, for a country's own reports are not enough; those from selected stations in the surrounding countries are needed in order to form a correct view of the changes that are taking place. Furthermore, these changes often take place so quickly that too much may happen without our knowledge if twelve hours pass without any observations being reported. Wireless telegraphy will assist in meeting such requirements, and each country will soon, it is hoped, send out the meteorological observations taken at some ten to fifteen of its selected stations four times daily at fixed hours. French observations are already being sent out thrice daily from the Eiffel Tower in this manner, but some organisation will be necessary to bring this into operation as a general practice. With foreign reports collected in this way, and special priority for the necessary number of inland reports, forecasts could

be got out more quickly and could be consequently of far greater utility.

It rarely happens that a meteorologist works on his own observations only; far more often he must utilise those of other observers, and for this reason, besides others, strict uniformity in the type of instruments employed, in the hours of observation, and in the control of the observer are essential. Changes of meteorological phenomena take place so rapidly that observations at different hours are seldom comparable, and any attempt to correct those of one to another introduces uncertainty into the result.

Only a small proportion of the observations which are taken can ever be printed and published, so all working meteorologists must often refer to the voluminous collection of manuscript data which every meteorological service accumulates. Where research into the problems of the atmosphere is to be actively carried on there must be free access to such a collection, as well as to a well-stocked library on the subject.

All these considerations indicate the desirability of a close contact and co-operation between all the meteorological services in a country, so that the whole material may be available to each, so that the scientific staff of each may be able to discuss the points which may arise, and that information may be more quickly and easily distributed, than if they worked apart and at a distance.

Aviation, with its prospect of long-distance communication, has rendered necessary a readjustment of meteorological relations within the Empire. Canada, South Africa, Australia, New Zealand, India, and Egypt and the Sudan have all their well-equipped meteorological services, which include networks of stations so selected as to represent most suitably the different meteorological conditions prevailing in those regions. In each there is a scientific staff studying the problems that arise or which affect the economic life of the country. Except as students of the same science the interests of each service have been somewhat diverse from the nature of the requirements which each had to meet, but in future we must organise the provision of all information that aviation may require, and since aviators are going to pass from continent to continent and from one country to another, uniformity of some kind must be attained in respect of the assistance that meteorology is to give.

Besides those already referred to, there are among the British Crown Colonies other wide networks of stations where meteorological observations are being taken and have been taken for many years. Many of these are situated in places of the highest meteorological interest, in mid-ocean, in the equatorial zone, etc., where the material for attacking many problems of the highest scientific and practical importance is to be collected by a skilful meteorologist of thorough scientific training. There are within the Empire about a thousand meteorological stations at the present time at which the principal meteorological elements are observed, and the great majority could without difficulty be developed, so as to co-operate effectively in the meteorological organisation of the Empire. So wide is their distribution, and so various is their location, on the sea-coast, in the interior of continents, in low valleys, high up in mountain ranges, in regions of heavy tropical rainfall, in the arid deserts of Africa and Asia, that hardly a problem in meteorology can be conceived the material for the solution of which could not be collected from them with the aid of effective support and efficient staff.

From the organisation necessary for Imperial co-operation to that of international co-operation is but a step, and the same requirements have to be considered; but here some additional complications, such as variety of units, have to be reckoned with. But these have been successfully dealt with in the past; and as for many years the international work of meteorological services has paved the way for steady advance in our science, we may look with confidence to even greater progress in the future.

The problems that press for early investigation are too numerous to recite, but a few may be mentioned. The study of the relation of meteorology to gunnery must be continued and the investigation of the many problems involved carried on by competent men.

The air-routes of aerial transport will have to be studied and all the information now available must be sorted out, investigated, and discussed in order that it may be put in the form most suitable for use by airmen. This will demand much additional observing at many places besides the discussion of existing material, but unless this is done as part of a concerted scheme much unnecessary expense will be incurred, and the results will fall far short of what they should be, since all the data must eventually be worked up in connection with that from other places, and if all is not of the same scientific standard it ceases to be comparable and must often be rejected in discussion.

Many of the stations in the Crown Colonies can afford most valuable information in this connection if expert meteorologists are available to carry out the work. An observant French traveller in Dahomey has remarked upon the presence of a steady north-easterly current at about 6,000 ft. to 7,000 ft. over the lower currents of the south-western monsoon of West Africa, and such information may be of material importance in this region.

Our forecasts have but tentatively extended to the upper air, and this subject has to be seriously studied, as it is one of extreme importance; but many and carefully designed experiments carried out by skilled meteorologists and aviators will be necessary to establish our knowledge of the currents of the upper air on a firm basis. Much valuable theoretical work has been done, but additional reliable material is needed for discussion. The observation of temperature at successive heights is a matter of great importance, and has been carried out by means of aeroplanes, but the continuance of this work which was easily arranged under war conditions should be ensured under peace conditions, and meteorologists will look to airmen for assistance and co-operation in this work.

While overland observations are numerous, and have been extended by means of *ballons-sondes*, aeroplanes, etc., to very great heights, our knowledge of the atmosphere over the sea is much less complete. By means of ships equipped for the purpose, such observations can be and have been made in certain parts, but this line of investigation must be extended if our knowledge is to be adequate.

Besides these more evident needs of aviation there are many problems of great practical importance which merit a closer and more thorough investigation than they have yet received. Among these may be suggested those violent disturbances known as hurricanes and typhoons. Recent theoretical investigations have thrown much light on their nature, and a further study of the evidence which exists should greatly add to our knowledge of them.

Variation of rainfall is always a matter of importance, and in countries where it is barely adequate for agriculture any diminution of it is a serious matter. In West Africa some observers have suggested that a gradual diminution of the annual rainfall is in progress, but this may be a slow oscillatory variation only. Anything that will throw more light on the conditions which influence the rainfall on the tableland of Abyssinia leads us to practical forecasting of the Nile flood and the monsoon rainfall of the Sudan. Already we know that the Atlantic stations and data from the eastern shores of South America furnish a partial guide of the probable development of these summer rains, so that the prospect of long-period forecasting, even for the lower latitudes, is bound up with investigations which must be world-wide in their scope.

The war has given a great impulse to meteorology by showing to all its possibilities, and aviation has made, and is still making, more and more demands upon it for information of every kind. Co-ordination between the services in each country and effective co-operation between the meteorologists in all parts of the Empire are the first essentials for meeting quickly and adequately these demands. There is an immense amount of work to be done, and if it is to be done economically and efficiently all must work together on a well thought out and co-ordinated plan

The "Manual of Meteorology" which the chairman, Sir Napier Shaw, has in hand, will be of the greatest value in the work before us, for it will place in the hands of every meteorologist and student of meteorology a masterly treatise on those aspects of our science which he has studied for years, and of which he is the acknowledged exponent.

DISCUSSION.

THE CHAIRMAN (Sir William Napier Shaw, Sc.D., F.R.S.), in opening the discussion, said perhaps, as indicating the point of view that must be borne in mind in comparing what was before the war with what should be after the war, he might briefly recall his recollection of an incident which Colonel Lyons had referred to in his paper, namely, the setting up of a service in the early morning. That service was now at 1 a.m.; previously it had been at 3 a.m. It began in the following way. He received a telephone message from an important south-coast town, from the meteorological observer there, reporting that a British airship had appeared, the commander of which, seeing that the observer had got some meteorological instruments and an anemometer, asked for a forecast for 4 o'clock the next morning and successive mornings until his requirements were satisfied. He (the Chairman) supposed that the discussion of the paper could not properly go on unless the audience appreciated some of the dismay which a request of that kind brought to the Meteorological Office at that time. The officer in command of the airship, seeing an anemometer and some meteorological instruments, thought that he was thereby

entitled to demand a forecast; whereas meteorologists considered that if a forecast was required, there had to be a collection of stations, and facilities for getting information from the stations to a central establishment; then somebody had to draw a map; then somebody else drew inferences from the map, and then telegraphic facilities were necessary in order to get the result of the map transmitted to the officer who wanted to navigate his airship. The request came to the Meteorological Office simply by telephone from the local observer, and the question was what was to be done in those circumstances? The only thing was to send somebody down to see what it all amounted to. That had been done, and from that time to the present there had been a service either in the middle of the night or in the early morning. It was from that point of view, not only the difficulty of dealing with recalcitrant weather but also the difficulty of making oneself understood and the methods understood by those whose interests required the latest and most valuable information as to weather, that he should like to offer a suggestion to the audience as to the point of view from which the very interesting paper of Colonel Lyons should be discussed.

Sir Frank Watson Dyson, F.R.S. (Astronomer Royal), thought the Meteorological Office should certainly be congratulated on the way in which it had risen to the occasion and had attacked the various problems submitted to it, and had supplied information of such a valuable character. He thought it could not be too strongly brought out that there was a generally prevalent idea that if an anemometer and a thermometer and a barometer were about, the person who had charge of them could forecast the weather; whereas, of course, it was a highly skilled operation, dependent on the comparison of a great many data. That brought him to the point which he thought was the really serious and practical one of the discussion, namely, that there were now in existence four different meteorological organisations. It was extremely important that they should be properly co-related, and it was equally important, or more important, that they should be put on a thoroughly scientific basis, and they ought to be properly co-ordinated. Colonel Lyons had referred to the variety of the operations in which meteorological data were required, and those operations would necessarily increase and be of importance in aviation, agriculture, and so on; and it was essential that there should be a real scientific basis in the institutions, and also that there should be a thorough co-operation and co-ordination between them.

Colonel L. P. Blandy, D.S.O., R.A.F., entirely agreed with the Astronomer Royal in what he had said regarding co-operation. There was always the great danger, when four different bodies were doing the same work, of four different aspects being obtained. If there was no co-operation or co-ordination, four different forecasts of the same weather were likely to be obtained, and then nobody would believe in any one of them. The different requirements of the British Empire, including those of aviation, had to be studied, and he thought the Government should proceed to put the whole matter on a proper scientific basis.

Mr. T. H. Blakesley remarked that no doubt co-operation between different establishments for meteorological purposes was, as for any other purpose, essentially desirable; but, he would ask, Was consistency to be found in any one? He desired to point out that there had been seen on the diagrams shown that afternoon the isobars, as they were called (and he thought the word "isobars" was one which most people knew the meaning of), expressed in millibars, and also another form of pressure given by the barometer. He happened to have noticed in the *Times* of one day that week, and in the *Morning Post* of one day the previous week, instructions said to have been received by the Meteorological Office as to the comparison of those two measures. He had not much to say about the *Times* definition, although he did not think it was advantageous to have new units in that way; but the unfortunate paper, the *Morning Post*, had half a dozen different definitions of it—that was to say, they had got the scale, which was in millibars, and had given various points of it in the other measure, in the mercurial inches, and the two scales did not hang together; they had no fixed proportion, and the consequence was they were not convertible *inter se*. He thought consistency might be maintained. Moreover, one of those systems was said to be a scientific measure of the weight of the air. Most people knew that the weight of the air did not vary *pari passu* with the pressure of it. He supposed the word "air" in meteorological matters meant the atmosphere and not the pure gases, and the air was a complicated system, and the pressure and the density were two totally different things; they could not be connected at all except by dragging in a number of conditions. As he had said, one of those systems was said to be a scientific mode of measuring the weight of the air, and at the same time it was said to be a mode of measuring the pressure. The word "millibar" was new to him, and he thought there was no necessity to add the word. The inches of mercury were quite sufficiently definite, and had the advantage that they could be more directly compared with anybody's private instrument.

Major F. G. Ogilvie, C.B., LL.D., desired to take the opportunity of emphasising the congratulations which had been conveyed to the Meteorological Office on the way it had risen to the occasion. He thought it must have been an extremely difficult matter to get together the *personnel* for such a Service as that which had been described. The Service had been a very large organisation, larger probably than people knew of until to-day. The

Service was one which had required a very great number of men who had scientific training, a training which did not, except in rare cases, include meteorology. That training had had to be brought to bear directly on meteorology, and he thought the securing in the first place of the men who had the necessary preliminary qualifications and promise, and, secondly, the training of those men, had been an achievement in regard to which the Meteorological Office had not been behind some of the Services that had attracted special attention in meeting new conditions. Then, again, he thought the work of the Meteorological Office during the war, as brought before them that afternoon, must have done a very great deal to secure the future of meteorology in this country. It had suffered in the past from the fact that the man in the street had had a very slight idea indeed of what it was all about. Now there were a very large number of men, who as officers, non-commissioned officers and men, had been brought personally into touch with meteorological results. The meteorological diagram was no longer something to be skipped; it was something which carried information to thousands where previously it only carried it to tens or hundreds. If there was, as he thought there was, a very much wider appreciation of meteorology as a science now than there was before, he believed there was every prospect that serious steps would be taken to make the best use of the opportunities—singularly promising and good opportunities—that this Empire had for the development of meteorology. Those were two points he thought which, although they were not essentially meteorological, did make a very great advance towards securing meteorology a future. One other contribution had been made to general knowledge that afternoon, which he welcomed very much. It was a well-known saying that a little learning was a dangerous thing; but they knew now that less learning might be a most valuable thing. It was curious that all the great advance of midnight services should have turned upon the fact that a particular individual, who was no doubt a first-class skipper of an airship, was entirely ignorant of meteorology. If that individual had only had a little knowledge of meteorology he would never have made the request he did, and then heaven only knew when the midnight services would have been instituted.

Mr. Carle Salter also conveyed his congratulations to Colonel Lyons on the very lucid and extremely interesting account of what many imagined was going on, but of which many knew so little. It had been a revelation to him at any rate that the Meteorological Services of the country had risen to the occasion in such a magnificent way.

Mr. Rudolf K. Lempfert said he hoped that when a more general organisation of the Meteorological Service was arrived at, more interest in the subject would be taken by the universities than had been the case in the past. From the experience gained in the Office, the educational science of meteorology had, strangely enough, found its way more into the elementary schools than into our other educational organisations. A great many of the elementary schools had come to the Office—or at least did so before the war—for information on various points, and gradually, in that sphere of the educational world, a good deal of interest had been taken in the subject; but the higher educational bodies, on which the Meteorological Office depended for progress, had comparatively little conception of its importance.

The Chairman, in proposing a hearty vote of thanks to Colonel Lyons for his interesting paper, said the development of public interest in meteorology was, he supposed, very markedly indicated by what had taken place in the *Times* during the last two days, following what had taken place in the *Morning Post* from January 1st. He had been always rather distressed at the old *Times* weather map. It seemed to him such an inadequate representation of the effort which was made to prepare the map. The scale and reproduction rendered it very difficult for anybody but a professional meteorologist to make very much out of it. That state of things had recently been remedied, so far as the *Morning Post* and the *Times* were concerned. They had succeeded in obtaining a reproduction of a map which now tossed the ball back to the Meteorological Office from the newspaper, and showed that the Office's next business was to get some more information from places that were outside that magic circle which was represented every day on those maps, and extend the map to the boundaries of the frame. It was no easy matter, but he supposed, with Colonel Lyons' assistance, it would be brought to pass. Then he hoped there would be some dissatisfaction expressed from some other quarters that would lead to further improvement in the representation of the weather for the benefit of the readers of newspapers, because the readers of newspapers represented the general public, and when the general public required information there was usually somebody who came forward to supply it. With regard to one point in Colonel Lyons' paper to which Mr. Lempfert had alluded, namely, the co-operation of the universities, he (the Chairman) did not propose himself to exonerate them at all for not having taken part in the study of weather, because there were no professional posts, or not a sufficient number of professional posts, in meteorology to make it attractive from that point of view. Our great schools of learning had something else to think about than identifying the particular posts and looking at them as the inducement to take up a particular study. They had duties of other

characters to consider besides the staffing of particular appointments. He had had a good deal of experience in trying to persuade universities to take up what had been a fascinating study from the dawn of history and what would become, he believed, more fascinating as time went on; they had always explained to him that the main reason for their not taking up the study of weather themselves was that they had not the money, and the suggestion had always been forthcoming that if he himself would find the money, or knew where the money could be found, they would do the rest. He spoke rather bluntly, because he thought it was just as well that one should be quite plain and straightforward about it. That, he thought, was the situation—that the universities had no conscientious objections to studying the weather, but they had not got the wherewithal adequately to pay the men who should take the subject up. Had they desired encouragement, he could point to the success of the two gentlemen who were Readers in Meteorology in the University of Cambridge on the foundation of Dr. Schuster, now Secretary of the Royal Society. One of those gentlemen was Lieut.-Colonel Gold in charge of the Meteorological section in France, now a D.S.O. and O.B.E., and the other was Major Taylor, who was Professor of Meteorology to the Flying Corps, and who had added immensely to the knowledge of the subject. If, therefore, the universities required a promise of distinction if they would give their attention to the study of the atmosphere, he could give them it with much confidence, pointing to the results which had already followed in the only two cases, both of which were successful. What more could they want? If he might sum up what Colonel Lyons had already said, the study of meteorology was a very intricate sort of indenture between the actual process of taking observations at observatories and stations of the one part, and the collection of the observations in a central office or elsewhere and the systematising and co-ordinating them of the second part, and the application of meteorological principles, which meant forecasting in one direction and climatology in another direction, of the third part, and the advancement of the science of meteorology as the only avenue to improving the other things of the fourth part. The organisation was not complete unless all four parts took their share and made their contribution, and the most difficult part of all was the advancement of the science of meteorology—that was to say, the understanding of the secret processes of weather. If that was left out of account, then the chance of improving the practical applications of the other three parts was nil. The advancement of the science of meteorology had to be definitely associated with the rest of the ordinary practical work of meteorology in order that a successful organisation might result.

The vote of thanks was carried unanimously.

OBITUARY.

Sir Edward Montagu Nelson, K.C.M.G.—Sir Edward M. Nelson, who died at Warwick on the 4th inst. at the age of seventy-eight, was elected a Fellow of the Royal Society of Arts in 1872.

Sir Edward and his brother, Mr. William Nelson, were pioneers in developing the frozen meat industry in Australia; and they were active in introducing frozen meat to the Continent. He received the honour of K.C.M.G. for his services to Australia in 1917. He was chairman and managing director of the Australian Chilling and Freezing Company, Limited, the Colonial Consignment and Distributing Company, Limited, Messrs. Nelson Brothers, and the Central Queensland Meat Export Company.

In addition to his business activities he took a great interest in municipal affairs. In 1892 he was Sheriff of Middlesex, and he was the first Mayor of Ealing. A few years ago he went to reside at Warwick, and was elected Mayor in 1917, and re-elected last November.

John Henry Master.—Mr. John Henry Master died on January 29th at his residence in Petersham, Surrey, in his eighty-eighth year.

The fourth son of the Venerable Robert Mosley Master, Archdeacon of Manchester, he was educated at Haileybury for the service of the Honourable East India Company. In 1852 he entered the Madras Civil Service, following the example set by his ancestors as far back as Sir Streynsham Master, who sailed for India in Cromwell's time, and was Governor of Madras in 1680. Mr. Master served in the North-West Provinces during the Mutiny. In 1869 he became collector of Bellary, and administered the district during the great famine. He retired in 1879.

He had been a Fellow of the Royal Society of Arts since 1893.

GENERAL NOTES.

Development of British Flax-growing.—The Development Commissioners, whose report for the year ending March, 1918, has recently been issued as a Parliamentary paper (118), recommended during the year advances amounting to £191,797. In the case of flax-growing, the expansion owing to war needs has led to such an increase of the undertaking that it is no longer of an experimental or educational nature. In the previous year the Commissioners granted £6,275 to the British Flax and Hemp Growers' Society, and in 1917-18 a supplementary grant of £15,450 was made for an extension of the Society's work in order to ensure a future supply of material for the production of aeroplane cloth, and to increase the growth of linseed as a feeding-stuff for stock. This was followed by an application for an advance

of £205,700, of which £200,000 was by way of a loan for the initiation of an extended programme for the cultivation of flax in Great Britain and its production into fibre. The growing of flax for fibre carried the undertaking outside the experimental or demonstrative sphere appropriate for aid from the Development Fund, and after the application referred to had been received arrangements were made for the whole of the Society's flax-growing work to be taken over by the Board of Agriculture.

DESTROYER-BUILDING IN THE U.S.A.—It formerly took two years to build an American destroyer. One has just been built in a little more than two months, says the *Engineer*. These craft, costing £400,000, have the engine-power of the old battleship "Maine" and the speed of a motor-boat. Experience has shown that they are most effective weapons against the submarine. When the country entered the war it succeeded in building a destroyer in eight months instead of two years. Then, with the speeding up of production, another was completed in six months. Finally, in the Mare Island Navy Yard, the destroyer "Ward" was launched seventeen and a half days after her keel was laid, and she was completed in seventy days.

RIVET-DRIVING RECORDS.—In the course of an article on "Engineering and Allied Trades in 1918," the *Engineer* quotes some remarkable figures in connection with rivet driving. "A Baltimore riveter drove 2,720 in nine hours. A London man took up the challenge and put in 4,276 in the same time. Then a riveter on the Clyde set up a new record with 4,422, and was beaten by a Baltimore man with 4,875. One of Vickers' riveters at Barrow easily broke that record with 5,894, but had to stand down for one of John Brown's men, who put in 6,783 at Clydebank, using a Boyer hammer worked from the shoulder and weighing 20 lb. Then the Boilermakers' Society stepped into the ring and declared such exhibitions were immoral from a trades-union point of view. So they ended."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

FEBRUARY 12.—SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research." The Most Hon. the MARQUESS OF CREWE, K.G., will preside.

FEBRUARY 19.—JOHN FRANCIS CROWLEY, D.Sc., M.I.E.E., "The Use of Electricity in Agriculture in Germany." SIR JOHN F. C. SNELL, M.Inst.C.E., will preside.

FEBRUARY 26.—W. L. HICHENS (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry." W. A. APPLETON, C.B.E., Secretary, General Federation of Trade Unions, will preside.

MARCH 5.—B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present." PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, will preside.

MARCH 12.—WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

MARCH 19.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

MARCH 26.—SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

APRIL 2.—W. NORMAN BOASE, "Flax."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

MARCH 13.—D. T. CHADWICK, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission."

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

FEBRUARY 25.—EDWARD J. DUVEEN, Fellow of the Royal Statistical Society, "Key Industries." W. A. S. HEWINS, M.A., late Under-Secretary of State for the Colonies, will preside.

MARCH 4.—PROFESSOR JOHN CUNNINGHAM MCLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

MAY 27.—SIR EDWARD DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced:—

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass and Some of its Problems."

H. Kelway-Bamber, M.V.O., "Railway Transport in the United Kingdom."

J. N. Spencer Williams, "The Hawaiian Islands and their Industries."

John Somerville Highfield, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

Leonard Erskine Hill, M.B., F.R.S., "Housing and Infant Mortality."

W. R. Gourlay, I.C.S., C.I.E., "The Need for a History of Bengal."

Sandford J. Kilby, "Indian Salt Manufacture."

Cantor Lectures.

Monday afternoons, at 4.30 p.m.

J. A. Fleming, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

Syllabus.

Lecture I.—February 10.—Electromagnetic waves—Æther theories: Maxwell's electromagnetic theory of light—Hertzian waves—Aerials and radiators in modern wireless telegraphy—Methods of creating damped and undamped waves for radiotelegraphy.

Lecture II.—February 17.—The transmission of long electromagnetic waves over sea and land—Penetration of high-frequency currents into conductors—The attenuation of radiotelegraphic waves—Diffraction of such waves round the earth—Effects of the atmosphere—Long-distance stations.

Lecture III.—February 24.—The detection of electromagnetic waves — Magnetic, electrolytic, thermionic, and crystal detectors — Receiving arrangements—The development of the thermionic detector—The Fleming valve—The three-electrode valve in radiotelegraphy and radiotelephony.

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

Monday, February 10 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Dr. J. A. Fleming, "Scientific Problems of Electric Wave Telegraphy." (Lecture I.)

East India Association, 7, Tothill-street, Westminster, S.W., 3.30 p.m. Mr. G. K. Devadhar, "Mr. Gokhale's Servants of India Society and its Work."

Geographical Society, Burlington-gardens, W., 8 p.m. Commander Roncagli, "The Adriatic: Outlines of its Physical and Strategic Geography."

Tuesday, February 11...London Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. Mr. H. Gordon Selfridge, "The Great Department Stores: their Origin and Architecture."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 7 p.m. Mr. A. Willcock, "Shop Fronts."

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. T. M. Morris, "Study of Electric Arcs and their Applications." (Lecture II.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Discussion on the Hon. R. C. Parsons' paper, "Centrifugal Pumps for dealing with Liquids containing solid, fibrous, and erosive Matters." 2. Mr. F. J. Mallett, "The Flow of Water in Pipes and Pressure Tunnels." 3. Mr. A. A. Barnes, "Discharge of Large Cast-Iron Pipe-Lines in Relation to their Age."

Colonial Institute, Central Hall, Westminster, S.W., 8 p.m.

British Women's Patriotic League, South Lodge, Rutland-gate, S.W., 3 p.m. Sir Sydney Olivier, "The West Indies and British Guiana."

Wednesday, February 12...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Sir Frank Heath, "The Government and the Organisation of Scientific Research."

Aëronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Dr. F. W. Aston, "Fabrics and Dope with special reference to Deteriorators and Tautness."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. The Viscountess Rhondda, "Women's Place in the Ministry of Health."

Thursday, February 13...Britain and India, 7, Southampton-street, High Holborn, W.C., 3 p.m. Miss E. Elder, "Indian Art."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Dr. C. W. Kimmins, "The Significance of Children's Dreams."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. W. Wilson, "The Movements of the Sun, Earth, and Moon." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. S. P. Hughes, "The Humours of Parliament."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W. 6 p.m. Lieut.-Colonel W. A. O'Meara, "The Functions of the Engineer: his Education and Training."

Historical Society, 22, Russell-square, W.C., 5 p.m.

Paint and Varnish Society, St. Bride Institute, Bride-lane, E.C., 7.30 p.m. Mr. C. E. Oliver, "The Perfections and Possibilities of Ready Mixed Paints."

Friday, February 14 ... Royal Institution, Albemarle-street, W., 5.30 p.m. Professor C. G. Knott, "Earthquake Waves and the Interior of the Earth."

Geologists' Association, at the Linnean Society, Burlington House, W., 7 p.m. Annual General Meeting and Exhibition.

Saturday, February 15...Royal Institution, Albemarle-street, W., 3 p.m. Professor H. P. Allen, "Bach's use of the Orchestra in his Works." (Lecture III.)

BANKING SUPPLEMENT.

London County Westminster & Parr's Bank

ESTABLISHED IN 1836. **LIMITED.**

HEAD OFFICE - - - - - 41, LOTHBURY, E.C. 2.
FOREIGN BRANCH OFFICE - 82, CORNHILL, E.C. 3.

AUTHORISED CAPITAL - £30,000,000.
SUBSCRIBED CAPITAL £27,323,960, IN 1,366,198 SHARES OF £20 EACH.
PAID-UP CAPITAL - £6,830,990 | RESERVE - - £7,430,086 10s.

WALTER LEAF, Esq., *Chairman.*
Sir MONTAGU CORNISH TURNER and ROBERT HUGH TENNANT, Esq., *Deputy-Chairmen.*

Joint General Managers:
F. J. BARTHORPE, J. W. BUCKHURST, J. C. ROBERTSON.

Secretary:
A. A. KEMPE.

BALANCE SHEET, 31st DECEMBER, 1918.

LIABILITIES.

		£	s.	d.
CAPITAL— Authorised	£30,000,000			
1,363,101 Shares of £20 each, £5 paid; 891 ,, ,, ,, issuable against Fractionable Certificates ... . 2,206 Shares of £20 each, £5 paid, issuable against outstanding Shares of Parr's Bank, Limited		6,830,990	0	0
RESERVE		7,430,086	10	0
CURRENT DEPOSIT AND OTHER ACCOUNTS, including provision for Contingencies ...		262,857,781	4	7
NOTES IN CIRCULATION IN THE ISLE OF MAN		17,263	0	0
ACCEPTANCES, ENDORSEMENTS, ETC. ...		9,276,487	15	5
REBATE ON BILLS not due		272,105	12	5
PROFIT AND LOSS.				
Net Profit for the year, including £184,598 18 11 brought from year 1917, £2,390,800 12 8. From this the following appropriations have been made:—				
Interim Dividend of 10 per cent. paid in August last	£495,070 19 3			
Reserve	600,000 0 0			
Bank Premises ...	300,000 0 0			
Bonus to Staff ...	140,000 0 0			
	£1,535,070 19 3			
Leaving for payment of a further Dividend of 10 per cent. on 1st February next		478,169	6	0
And a Balance to carry forward		377,560	7	5
		£287,540,443	15	10

ASSETS.

	£	s.	d.
CASH— In hand and at Bank of England	47,476,604	2	8
Money at Call and Short Notice	36,970,158	10	7
	84,446,762	13	3
BILLS DISCOUNTED	60,528,721	14	6
INVESTMENTS— Consols and War Loan and other Securities of, or guaranteed by, the British Government (of which £1,212,413 is lodged for Public Accounts, and for Note Issue in the Isle of Man)	45,503,257	11	4
Indian Government Stock, and Indian Government Guaranteed Railway Stocks and Debentures	178,101	0	0
Colonial Government Securities, British Corporation Stocks, and British Railway Debenture Stocks	523,277	10	8
Other Investments	872,185	19	7
LONDON COUNTY AND WESTMINSTER BANK (PARIS) LIMITED— 8,000 £20 Shares, fully paid ... 32,000 £20 Shares, £7 10s. paid ...	400,000	0	0
ULSTER BANK, LIMITED— 199,542 £15 Shares, £2 10s. paid ...	1,908,120	7	6
ADVANCES TO CUSTOMERS AND OTHER ACCOUNTS (including pre-moratorium Stock Exchange Loans)	80,973,191	11	2
LIABILITY OF CUSTOMERS FOR ACCEPTANCES, ENDORSEMENTS, ETC., as per contra	9,276,487	15	5
BANK AND OTHER PREMISES (at cost, *less* amounts written off)	2,930,337	12	5
	£287,540,443	15	10

WALTER LEAF, M. C. TURNER, R. HUGH TENNANT, } *Directors.*

F. J. BARTHORPE, J. W. BUCKHURST, J. C. ROBERTSON, } *Joint General Managers.*
W. J. WOOLRICH, *Chief Accountant.*

AUDITORS' REPORT.

We have examined the above Balance Sheet and compared it with the Books at Lothbury, Lombard Street and Bartholomew Lane, and the Certified Returns received from the Branches.

We have verified the Cash in hand and Bills Discounted at Lothbury, Lombard Street and Bartholomew Lane, and the Cash at the Bank of England.

We have examined the Securities held against Money at Call and Short Notice, and have verified the Investments of the Bank.

We have obtained all the information and explanations we have required, and in our opinion the Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Company's affairs according to the best of our information and the explanations given to us, and as shown by the Books of the Company.

TURQUAND, YOUNGS & CO.,
KEMP, SONS, SENDELL & CO.,
PRICE, WATERHOUSE & CO.,
STEAD, TAYLOR & STEAD, } *Chartered Accountants.*
Auditors.

LONDON, 21st *January*, 1919.

BANKING SUPPLEMENT.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—February 7, 1919.

No. 3456. FEBRUARY 14, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2.

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,456. VOL. LXVII.

FRIDAY, FEBRUARY 14, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 17th, at 4.30 p.m. (Cantor Lecture.) J. A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." (Lecture II.)

WEDNESDAY, FEBRUARY 19th, at 4.30 p.m. (Ordinary Meeting.) JOHN FRANCIS CROWLEY, D.Sc., M.I.E.E., "The Use of Electricity in Agriculture in Germany." SIR JOHN SNELL, M.Inst.C.E., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 12th, 1919; The Most Hon. the MARQUESS OF CREWE, K.G., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Alcock, Walter James, London.
Almond, Rev. George, Nebraska, U.S.A.
Armstrong, Charles Hendrie Barrington, M.D., J.P. Kingston, Jamaica.
Braithwaite, Albert, Cobham, Surrey.
Clark, Joseph, Winnipeg, Canada.
Driver, James Hutchinson, J.P., Woking, Surrey.
Ironside, E. Allan, London.
Marple, George Smith, Sheffield.
Marsh, J. Parker, Sheffield.
Martin, John W., Belfast.
Martin, Major Robert, V.D., J.P., West Hartlepool.
Perks, William, Worthing.
Raffé, Walter George, A.R.C.A., London.
Solomon, G., Karachi, India.

The following candidates were balloted for and duly elected Fellows of the Society:—

Bitterling, Charles Frederick Augustus, Nottingham.
Hammick, Sir Murray, K.C.S.I., C.I.E., London.
Hetherington, John, London.
Hubbard, Major Reginald Kirshaw, R.A.S.C., B.E.F., France.
Hugon, John Herbert, A.I.M.M., A.R.S.M., Withington, Manchester.
Major, Mark B. F., London.
Rose, Cav. Ing. Henry G., Genoa, Italy.
Stevenson, William, F.C.S., London.
Whitaker, George Herbert, M.R.C.S., L.S.A., London.
Williams, Geoffrey Sydney, London.

A paper on "The Government and the Organisation of Scientific Research" was read by SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research.

The paper and discussion will be published in the *Journal* of the 21st inst.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING.

Wednesday afternoon, February 5th, 1919; the Right Hon. the LORD LAMINGTON, G.C.M.G., G.C.I.E., in the chair.

THE CHAIRMAN, in introducing the reader of the paper, said he was particularly interested in the subject to be discussed, as when he was Governor of Bombay the question of improving the quality of cotton was constantly before the Government, and the result of experiments then made led to the successful introduction of a longer fibre cotton in Bombay and other parts of India than had up to that time been grown. It was particularly appropriate that the subject should be discussed under the auspices of the Society, because as long ago as 1783 the Society was then so progressive in its character that it offered a gold medal, a silver medal, and certificates, to any person who brought forward a system which would result in the extraction of oil from cotton seed, thus benefiting mankind.

The paper read was—

THE REMOVAL OF THE RESIDUAL FIBRES FROM COTTON SEED AND THEIR VALUE FOR NON-TEXTILE PURPOSES.

By Ed. C. de Segundo, A.M.Inst.C.E., M.Inst.Mech.E., M.I.E.E.

The vital importance of developing the natural resources of the Empire upon the conclusion of peace in every way and in the greatest possible measure, makes it hardly necessary to offer any apology for directing attention to one of the world's largest neglected products, the potential value of which has long been recognised in scientific circles, but which has only recently been rendered available in commercial quantities for industrial purposes owing to the successful introduction of mechanical appliances for the recovery of this product in a merchantable form at a low cost for power and labour. I allude to the short cotton fibres of the woolly varieties of cotton seed, which escape the action of the gin and of any subsequent saw-linting operations. By the expression "residual fibres," however, I mean *all* the fibres retained by the cotton seed after ginning.

For all practical purposes, cotton seed may be divided into two categories: (*a*) Bald (or black) seed, comprising those varieties from which the whole of the staple is readily detached by the gin, leaving the seed practically denuded of any fibre, and (*b*) woolly (or white) seed, comprising those varieties which, in addition to the staple of spinnable length removed by the gin, are covered with an undergrowth, as it were, of short cotton fibre, amounting, in some varieties, to 12 per cent. of the total weight of the seed.

World's Crop of Cotton Seed.

Professor Wyndham H. Dunstan, C.M.G., LL.D., F.R.S., Director of the Imperial Institute, gives the distribution of the world's crop of cotton seed in 1913–14 as follows:—

	Tons.
United States	5,620,000
India	2,120,000
China	1,600,000
Egypt	620,000
Russia	440,000
Other countries	600,000
Total	11,000,000

With the exception of Egypt, the seed produced in the above countries is practically all of the woolly variety.

The figure for the production in the United States includes a small quantity of Sea Island or bald seed, about 50,000 tons. The West Indies produce a negligible quantity of bald seed. Of the 620,000 tons of seed coming from Egypt and the Sudan, probably 600,000 tons are bald, or practically so. Hence, the really "bald" seed produced in 1913 was about 650,000 tons out of 11,000,000 tons, or about 6 per cent.

Professor John A. Todd, in an appendix to his valuable work on "The World's Cotton Crops," gives figures from which the average of the world's crop of cotton seed for ten years from 1904 to 1914, calculated on the basis of 1,000 lb. of seed per bale (500 lb.) of cotton, works out to about 10,000,000 tons of 2,240 lb. But latterly the total production has been increasing, while the Egyptian crop of bald seed has remained practically stationary, so that it may be assumed that to-day the proportion of woolly seed grown is probably over 95 per cent. of the world's crop.

The above table indicates that by far the greater proportion of woolly seed is produced in the United States of America, and that the next most important cotton-growing country is India.

In India, however, the yield of lint cotton is, on the average, under 100 lb. per acre, whereas in the United States the average yield is 170 to 180 lb. per acre. Moreover, the average length of staple of Indian cotton is considerably below that of American. The reasons for this are, to a great extent, understood, but any consideration of this aspect of the subject falls outside the scope of this paper. It may, however, be remarked that there would appear to be no insuperable obstacle in the way of materially increasing both the length of the staple and the yield per acre in India, and it is to be hoped that the efforts which are now being made to accomplish this, and also to improve the character of the Indian staple, may receive the support and encouragement they deserve.

In a paper read before the Indian Section of the Royal Society of Arts on December 14th, 1916 (*Journal* No. 3345, Vol. LXV.), Professor John A. Todd stated that the world required a progressive increase of something like one million bales of cotton per annum, and gave cogent reasons for the desirability of developing other sources of supply outside of America. After reviewing the various sources whence the increasing needs of the cotton industry might be supplied within a reasonable time,

Professor Todd said: "It is, therefore, to India that we must turn as the only hope for relief in the way and to the extent which the cotton industry requires so urgently."

Mr. Hodgkinson, the representative of the Lancashire spinners at the recent Commission appointed to examine into the conditions of cotton-growing in India, is reported to have stated in evidence that Lancashire was dependent for 80 per cent. of its supplies upon the United States, whence some 3¼ millions of bales were drawn annually by British spinners.

It is a little difficult to understand why this condition of things should have been permitted to continue, in view of the fact that the cotton crop in the United States is known to be liable to very considerable fluctuations owing to climatic and economic conditions, and that in many parts of the Empire the American variety of cotton could be successfully cultivated.

The evils attendant upon putting 80 per cent. of Lancashire's eggs—so to speak—into one basket have become intensified of late, owing to the rapid increase in the proportion of the cotton grown in the United States which is being spun in American mills. The relation between the American cotton crop and the quantity taken by American mills from 1865 to 1916 is shown in the diagram below, from which it will be seen that the percentage of the crop taken by American spinning mills has increased since about 1900 from about 34 per cent. to over 54 per cent.

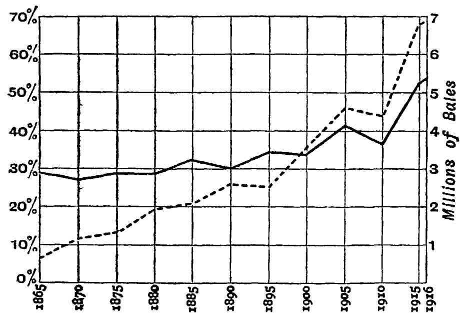


FIG. 1.

It may fairly be said to be improbable that the cotton crop of the United States will be very largely increased in the future, owing chiefly to the increasing difficulty in obtaining suitable labour, and to the higher pay demanded. Possibly some genius may perfect a mechanical cotton picker, which would materially alter the whole aspect of affairs in regard to the cultivation of cotton, not only in the United States but throughout the world.

Cotton of the American variety is a necessity for Lancashire, and, therefore, it is unquestionably the part of wisdom to stimulate the cultivation of American cotton within the British Empire in the greatest possible measure, to the end that Lancashire may be in a position to draw her supplies from more sources than one, and thus diminish the many evils attendant upon the present variations in the available supply from the United States. It is, therefore, gratifying to note that within the last three or four years the cultivation of the American variety in India has met with success, and if the necessary precautions are taken, and the necessary encouragement given, there is no reason why a new era in cotton cultivation should not open in India.

SUPPLY OF WOOLLY COTTON SEED FOR BRITISH CRUSHING MILLS.

Although it is recognised that the milling of cotton seed for the production of oil and cake is most advantageously carried out in the country of origin, some years must necessarily elapse before the development of the cotton-seed oil industry in such countries is likely to reach a stage at which even the seed now produced will be absorbed, and if steps be taken to increase the cultivation of the American type of cotton within the Empire it would seem a safe presumption that for many years to come increasing quantities of woolly cotton seeds will become available for milling in British seed-crushing mills.

Practically the whole of the cotton-seed oil produced is obtained by one of the two following methods:—

(*a*) By crushing the seed whole, as practised hitherto in Great Britain, and generally throughout Europe; and (*b*) by the American system of decorticating the seed, separating the kernels (or meats, as they are called) from the containing envelope, or shell, of the seed, and crushing the naked kernels.

The American system, however, can only be efficiently employed where the woolly varieties of cotton seed are in question, and up to within a year or two of the outbreak of the war, the varieties of cotton seed obtainable by seed crushers in Great Britain in sufficient quantities, and at a suitable price, were limited practically to Egyptian seed, and to a small fuzzy seed exported from India, which is known in the trade as "Bombay Seed,"

neither of which can be efficiently decorticated by any commercially established process, as both retain but an inconsiderable amount of residual fibre after ginning.

The two chief reasons why cotton seed is crushed whole in Great Britain are (1) because, under prevailing market conditions, the cotton seed hitherto obtainable by British seed crushers in sufficient quantities has been of a kind which does not lend itself to the American system of decortication, and (2) because the presence of the shell imparts certain features of value to the cake as a feed for cattle, and particularly for sheep.

Seed crushed on the British system is passed through the usual cleaning machines designed to remove large pieces of foreign matter which are invariably found in seed as shipped, the seed is then sent straight to the crushing rolls, the function of which is to break down the oil cells in the kernel, and the crushed seed—meats, shell, fibre, dirt, and all—go into the kettles, and thence to the presses. The oil extracted is prejudicially affected by the bruising of the shell in the process of pressing, and by the tarry and other compounds contained in the shell, and until comparatively recently most of the cotton-seed oil made in Great Britain found its way to the soap-boiler, or was used for purposes other than for human consumption. Greatly improved processes of refining have, however, been introduced of late, and British cotton-seed crushers now produce an edible oil of very high quality (though, perhaps, not so high as that of the best refined American "decorticated" oil). The residue of the seed, after the oil has been extracted, consists of the kernel-remains, the shell, the fibre and the dirt, all compounded together, and constitutes the "Bombay cake" or "Egyptian cake" of commerce, which is used exclusively as a cattle feed, the nutritive value of which is necessarily lowered by the presence of the cotton fibre, which is practically non-digestible.

The products obtained by the decorticating method from the woolly seed grown in the United States are in every way superior to those yielded by crushing the seed whole, but American seed-crushers have the important advantage over British of being in a position to crush *fresh* seed, whereas the British seed-crusher has to deal with seed which may have been months in storage and in transit. The oil from the decorticated seed being squeezed out of the naked kernel, is not vitiated by any of the deleterious matter contained in the shell of the seed, except in so far as portions of the shell (or decorticated hulls) may fall through the meshes of the shaking sieve, after issuing from the decorticating machine, and thus become mixed with the kernels. With up-to-date decorticating plant, operated by a careful and intelligent mill superintendent, the oil produced from sound seed is very pure, and should not suffer a loss of more than 6 per cent. or 7 per cent. in refining, whereas the loss in refining oil produced by the British system is about 11 per cent., and often higher, owing, to some extent, to the deterioration suffered by the seed during the long sea voyage to England. Refined American oil is an edible oil admittedly unrivalled for the manufacture of margarine, compound lard, etc. When the woolly seed is carefully and efficiently decorticated, the cake produced, consisting simply of the pure kernel-remains, is a very high-grade product, showing on analysis about 45 per cent. of protein and 6 per cent. of fat. British undecorticated cake necessarily contains a lower percentage of fat and a much lower percentage of protein, due to the presence of the non-protein-containing shell, etc.

In the best American decorticating practice, the proportion of oil left in the cake should not exceed about 6 per cent. During the war American seed-crushers have turned out decorticated cake with 5 per cent. or under of oil. But this does not necessarily mean that a higher percentage extraction of oil has been attained. Owing to the close linting of the seed during the war, the hulls, having less fuzz attached to them, are not so efficiently sifted out from the meats, and thus the material crushed for oil has been a mixture of meats and hulls (approximating to the British system), instead of meats alone (theoretically the American system). The cake produced under such conditions consists, therefore, of kernel-remains plus hulls and hull-shell; the latter absorb little oil, hence the percentage of oil in the so-called "decorticated" cake of to-day is naturally lower compared with that in true "decorticated" cake consisting of kernel-remains only. It must therefore be borne in mind that the "war-cake" is not representative of what has hitherto been defined in the trade by "American decorticated cake." British undecorticated cake, which consists of the kernel-remains *plus the whole of the shell*, sometimes analyses less than 4¾ per cent. of oil.

It is doubtful whether, with the hydraulic presses now in use, the degree of expression

of oil from pure meats could economically be carried further than that which leaves 6 per cent. of oil in the cake, although it is claimed with a certain type of cage press the oil left in the cake can be reduced to 4 per cent.

Cotton-seed Flour for Human Consumption.

A highly nutritious flour suitable for human consumption has been produced in large quantities in America during the war from the residue of the meats after the oil has been extracted. This flour, which, it is stated, has been recommended by the United States Government as a diluent for wheat, is being manufactured in large quantities in the United States. It is called "Allison" flour in honour of its originator, the late Colonel J. W. Allison, of Ennis, Texas. It contains about 50 per cent. of protein and 8 per cent. of fat, and is practically starch-free. Wheat flour, as is well known, shows on analysis about 11 per cent. of protein, about 2 per cent. of fat, and contains a high percentage of starch. The coefficient of digestibility of the protein in Allison flour is stated to be about 88 per cent., while that of the protein in wheat flour is about 94 per cent. Thus, the protein and fat content of cotton-seed flour is about five times that of wheat flour, and while, on this account, bread should not be made solely from cotton-seed flour (except under medical advice in cases where a starch-free diet is a necessity), cotton-seed flour is eminently suitable for mixing with wheat flour and potato flour. By the judicious use of cotton-seed flour a wholesome and palatable bread can be made, possessing the same nutritive properties as the all-wheat loaf, while effecting a considerable reduction in the actual quantity of wheat flour used. For example: A mixture of 5 per cent. cotton-seed flour, 10 per cent. potato flour, and 85 per cent. of wheat flour (percentages calculated on the weight of solids only), would produce a loaf containing a rather higher percentage of protein than that found in the all-wheat loaf of pre-war days. As the wheat consumption in this country was over 6,000,000 tons per annum, on the average, over a period of years immediately preceding the war—of which about 5,000,000 tons had to be imported—the possibility of effecting a saving of 15 per cent. of our normal requirements of wheat flour is a matter to which serious consideration might usefully be given. I have dealt at some length with the properties of cotton-seed flour in a paper read before the London Section of the Society of Chemical Industry on March 25th, 1918.

Higher Percentage of Oil Obtainable by Decorticating.

Although not strictly relevant to the subject of this paper, it may be of interest, in view of the quantity of woolly cotton seeds which British mills will probably have to deal with soon, to point out that an appreciably higher percentage of the oil contained by the kernel of the woolly cotton seed should be obtainable by the decorticating method than by the British method of crushing the seed whole. This can be shown in the following manner:—

Starting with 100 tons of, let us say, American Upland cotton seed, as received by the seed crusher from the ginneries, analysing on the average say 18 per cent. of oil on the total weight of the seed, there should be produced by decortication, on the average, 43·7 tons of cake (containing say 6 per cent. of oil) and 33 tons of decorticated hulls, these latter containing, on the average, 0·7 per cent. of oil (absorbed during the process of decortication by contact with the naked kernels liberated in the decorticating machine). The oil expressed is the difference between the oil content of the meats and the sum of the quantities of oil left in the cake and the hulls. The quantity of oil expressed is, therefore, 18 tons $-$ ($43·7 \times 0·06 - 33 \times 0·007$) or 15·15 tons.

For the reasons above mentioned, woolly cotton seed of the American Upland variety has not been crushed in Great Britain on any large scale, and we must therefore have recourse to a process of deduction in order to arrive at the quantity of oil and cake that would be produced from such seed were it crushed whole on the British system. We can get at it with sufficient accuracy in the following manner:—

Theoretically, the oil expressed on the British system is simply the difference between the weight of the seed crushed and the weight of the cake produced. In practice, however, it is found that the sum of these weights is somewhat greater than the original weight of the seed, due to moisture incorporated in the cake during the crushing process. We can therefore write:—

Oil expressed equals weight of seed, less weight of cake (the latter reduced to normal dryness), and also,

Oil expressed equals oil contained in seed, less oil left in cake (which may be taken as $4\frac{3}{4}$ per cent. of the weight of the cake).

By equating these two expressions and putting x for the weight of cake produced, we have—

100 tons seed $-$ x tons cake $=$ 18 tons oil $-$ (x tons cake $\times$ 0·0475) whence x (or weight

of cake) is 86·09 tons, and the oil expressed is 18 tons $-$ 86·09 $\times$ 0·0475, or 13·91 tons, as against 15·15 obtained from seed analysing the same oil content by the American system.

While, perhaps, this only brings out a relation which seed-crushers do not appear hitherto to have considered with exactness, British seed-crushers are nevertheless quite alive to the general advantages of decorticating the woolly varieties of seed, and to the superiority of the products obtained; nor have they clung to the system of crushing the seed whole, merely out of disinclination to march with the times, or from any other form of prejudice. But owing to the changes in the economic situation brought about by the war, a new era in the cotton-seed crushing industry is about to open out in Great Britain, and indications are not wanting that those chiefly concerned are preparing to make the necessary modifications in their plant and machinery as and when they are called for. The utilisation of the hitherto neglected residual fibres should then become a prominent factor in oil-mill economics in Great Britain.

This somewhat lengthy preamble has been necessary in order to enable those of the audience who are not conversant with the details of these two methods of crushing cotton seed, to follow the discussion of the principles underlying the system of turning to commercial account these residual fibres on woolly cotton seeds when treated either by the British or the American method.

Defibration of Seed to be Crushed Whole.

So far as the British method is concerned, it is clear that while the presence of *shell* in the feeding cake has certain advantages, the presence of *cotton fibre* cannot be other than detrimental, and, therefore, the greater the degree to which the woolly cotton seed is denuded of residual fibres before being crushed for oil, the more suitable does the seed become for the production of oil and cake, because cotton fibre is practically pure cellulose, and its presence in the cake detracts not only from the appearance, but from the nutritive value of the cake as a cattle food. Mr. C. F. Cross, F.R.S., the well-known chemist, says of this cotton fibre that it "is resistant, or indigestible, and lowers the value of the cake, not merely in proportion to the dilution of the digestible matter, but also by its undesirable features in relation to the digestive tract and processes of the animal." In any case, the less fibre left in cake fed to cattle the better suited it will be for the purposes for which it is sold, and this is reflected in the higher price obtained in the market for lint-free cake made from Egyptian seed (which is a bald seed) as compared with that obtained for the more or less woolly "Bombay" cake, which is made from the small fuzzy Indian seed above alluded to. The defibration of woolly seed would render its physical condition comparable with that of Egyptian seed, and produce cake similar to "Egyptian" cake.

Defibration of Seed to be Decorticated.

In the American decorticating system a certain amount of fibre must be left on the seed, so that the hulls, when produced, may be sufficiently woolly to felt readily together and thus travel over the shaking sieve, while the meats drop through the meshes. Beyond a certain point, the less the quantity of fibre on the seed the more easily will the hulls fall through the sieve with the meats, thus vitiating the separation.

Owing to the character of the fibre which grows on American Upland seed, it is found that in the United States, where the saw-gin is almost universally used, a certain proportion of the residual fibres which escape the action of the saw-gin, are of sufficient length to make it worth while to recover them by means of a second process, for which purpose several types of saw-linting machines have been successfully devised, and are largely used in oil-mills in the United States. The cotton fibres recovered by such machines are known in commerce by the name of "linters," but it will readily be imagined that the grade and character of "linters" varies within wide limits.

Some fifteen years ago, when a high degree of efficiency in decortication was aimed at by oil-millers, the quantity of linters taken off American Upland seed, prior to decortication, did not exceed 1½ to 2½ per cent. of the weight of the seed. The quality of such linters was very good, and the product commanded a high price. The quantity of linters taken off the seed crept up gradually, to about 70 lb. to 90 lb. per ton of seed, just before the war, and the unprecedented demand for cotton fibre for the manufacture of explosives, caused by the war, resulted in a large increase in the linters produced, the average during last season being 148 lb. per ton (2,000 lb.) of seed, or 7½ per cent. of the total weight of the seed. This season (1918–1919)

the Government of the United States ordered that, wherever possible, 145 lb. of lint per ton of seed were to be removed before the seed is crushed, but owing to the suspension of hostilities this order has been rescinded, and the degree of linting reduced to not more than 75 lb. per ton (2,000 lb.) of seed.

In these circumstances, the diminished proportion of residual fibre left upon the seed made it impossible to maintain the old standard of purity in oil and cake, owing to the increasing proportion of hulls that fall through the meshes of the shaking sieve and become mixed up with the meats. Hence, the official definition of "prime cotton-seed cake" and "choice cotton-seed cake" in the United States has had to be considerably modified during the last year or two.

The effect of the gradual increase in the "closeness" of the linting of the seed is shown in the following table, the figures in which are quoted, or deduced, from the official reports of the United States Census Bureau:—

		1898-9.	1908 9.	1913-14.	1916-17.
I.	Seed crushed— tons (2,000 lb.)	2,400,000	3,670,000	4,800,000	4,500,000
II.	Linters produced— bales of 500 lb.	114,000	330,000	668,000	1,332,000
III.	Linters produced— pounds per ton (2,000 lb.) of seed	24	45	68	148
IV.	Hulls produced— tons (2,000 lb.)	1,170,000	1,330,000	1,403,000	968,000
V.	Hulls produced— pounds per ton (2,000 lb.) of seed	940	720	580	420
VI.	Cake and meal produced— pounds per ton (2,000 lb.) of seed	700	900	910	990
VII.	Crude oil— average percentage of weight of seed	15	15	15	15·6
VIII.	Percentage of protein in cake	47	45	45	37

It would at first sight appear that the difference between the weight of the residual fibres on the ginned seed and that removed by the saw-linting machines before decortication must remain upon the decorticated hulls (subject, of course, to some slight diminution due to fibres escaping into the air or being rubbed off the hulls in transit, which, however, may be neglected); but this is not the case, because, in proportion as the seed is denuded of its residual fibres, the hulls produced in the decortication of the seed will be less woolly, and will therefore fall through the meshes of the shaking sieve in correspondingly increasing amount, together with the meats. This is indicated by the figures in lines VI. and VII. of the table on this page, which give the quantities of cake and meal produced, and the percentage of oil extracted. It will be seen that whereas from 1898 to 1917 the average percentage extraction of oil only increased from 15 per cent. to 15·6 per cent., the quantity of cake and meal produced rose from about 700 lb. to nearly 1,000 lb. per ton of seed, the increase in weight being attributable to the admixture of hull and hull-shell with the meats.

The degradation of the meats by the presence of increasing quantities of the hull is also indicated by the figures in line VIII. The percentage of protein in the meal did not begin to drop materially until the gigantic demand for cotton fibre for explosives caused the United States Government to encourage close linting of the seed. According to a well-known authority, the average protein content of meal made from the cake now produced in the United States is probably no higher than 37 per cent., whereas in olden days it was 47 per cent., and in average practice for many years before the war it was 45 per cent.

Quantity of Residual Fibre on Ginned Cotton Seed.

The quantity of cotton fibre left upon Egyptian, Sea Island, and some varieties of Brazilian and West Indian seed, after ginning, is so small that it does not pay to recover it. But, as has been pointed out above, these varieties of seed represent in the aggregate only a small fraction of the world's crop.

American Seed and Cognate Varieties.

American Upland seed, which is typical of the varieties of woolly seed grown in Uganda,

West Africa, Brazil, the United States of America, and in some parts of the Sudan, Russia, the Caucasus, Smyrna, etc., may be taken to retain, after ginning, short cotton fibres to the extent of from 10 per cent. to 12 per cent. of the total weight of the seed.

India.

The quantity of short cotton fibre left upon Indian cotton seed after ginning seems to vary considerably. One authority puts it at from 8 per cent. to 12 per cent. of the total weight of the ginned seed. Another estimates it at about $3\frac{1}{3}$ per cent. The only Indian seed used hitherto in the crushing industry in Great Britain is known in British markets as "Bombay" seed, which does not retain more than 2 per cent. of short lint calculated on the total weight of the seed.

During the past few years the cultivation in India of the American variety of cotton has been considerably extended. According to the Indian Government returns, about 400,000 bales (of 500 pounds) of Cambodia seed were grown in 1917, corresponding to the production of about 250,000 to 270,000 tons of seed. Cambodia seed resembles the American Upland closely, and the seed may therefore be taken to retain after ginning from 10 per cent. to 12 per cent. of its total weight of short lint.

Apparatus for and Methods of Recovering the Residual Fibres in the most Efficient Manner.

The potential value of the short cotton fibres left upon woolly cotton seeds in the manufacture of paper, explosives, and other cellulose derivatives, has been recognised for thirty years past, and innumerable attempts have been made on both sides of the Atlantic to devise machines for obtaining the short lint in a merchantable form and at a sufficiently low cost. The efforts of inventors and others were directed in the first instance to the construction of machines for separating short cotton fibres from the decorticated hulls. Very large sums of money were spent both in Germany and in the United States in the endeavour to devise machinery and apparatus which would deliver the cotton fibre free from pieces of the broken hull. For many years all such attempts proved fruitless on a commercial scale, the machines possessing what has been termed the "fatal defect" of delivering the hull-fibre mixed with pieces of the shell and other foreign matter, the presence of the shell, etc., necessitates stronger doses of caustic soda and bleaching powder in the process of chemical refinement than are required with shell-free fibre, and this drastic treatment operates to reduce the yield in cellulose. In due time, however, this problem was solved, and the now very rapidly increasing application of these residual fibres to industrial purposes may be said to have begun in the year 1909, when the first hull-defibrating plant in Europe was set to work at the cotton-seed oil-mill of the Huileries Darier de Rouffio in Marseilles. The installation of this plant was largely due to the energy and enterprise of the managing director, Monsieur Georges Oppermann, who—it may to-day be expedient to state—is a Frenchman of Alsatian origin, and has gained many high distinctions during the war as commander of an air squadron in France.

In the autumn of the year 1912 a hull-defibrating factory on a commercial scale was established at Memphis (Tennessee), in the United States, entirely by private British enterprise. During the following year the capacity of this plant was largely increased, also by British capital. The hull fibre produced by these machines has yielded, in competent hands, about 75 per cent. in bleached pulp (air-dry weight on air-dry weight). The first papermakers to use this material on continuing contract were Messrs. Blanchet Frères Kléber & Cie, of Rives-sur-Fure, France (now the Société Anonyme des Papeteries de Rives). Subsequently British papermakers followed their example, and when the war broke out several papermakers in England and Scotland were using this material regularly, the hull fibre being shipped in bales from the factory at Memphis. In the United States the hull fibre found a market chiefly for the manufacture of explosives and of vulcanised fibre. During the war this factory has supplied upwards of 8,000 tons of hull fibre to the Du Pont de Nemours Powder Company of America for the manufacture of nitro-cellulose powders and explosives.

The successful removal of the short fibre from the decorticated hulls in the United States led to efforts being made in England in the summer of 1913 to devise a machine for the removal, direct from the woolly seeds, of the residual fibres retained after ginning which could not be removed in a perfectly clean condition by any of the saw-linting machines used in oil-mills. The need for such a machine was suggested by the very rapid increase in the

cultivation of the American variety of cotton in the Crown Colony of Uganda, from which source about 18,000 tons of woolly cotton seed were exported during 1913. Judging by the rate of progress maintained during the few years immediately preceding the war, it is probable that, but for the outbreak of hostilities, Uganda would now be producing some 50,000 tons or more of woolly cotton seed per annum.

These efforts led to a seed-defibrating machine being worked out which delivers the lint-product free from seed-debris or other foreign matter. The lint-product of this machine is called "seed-lint," to distinguish it from the lint-product obtained from the decorticated cotton-seed hulls, which is known as "hull-fibre."

The seed-defibrating machine you see here to-day has been constructed specially for demonstrating the process at this meeting, and I will now show it to you in operation defibrating "Bombay" cotton seed. This constitutes a very severe test of the powers of the machine, owing to the very small quantity of residual fibre retained after ginning by this variety of seed. In fact, I do not think I shall be going too far in saying that the result you will see to-day has never before been achieved.

[The machine was set in action, and samples of the seed before and after defibration, and also the residual fibres removed, were handed round for inspection.]

Seed-lint (the product you have just seen made) has been exhaustively examined by Mr. C. F. Cross, F.R.S. (of the firm of Cross and Bevan), whose analyses show a cellulose concentration as high as 87 per cent., or within a few per cent. of the cellulose yield obtained from raw long cotton.

Messrs. Clayton Beadle & Stevens, whose researches into the value of these short cotton fibres in the manufacture of all-rag papers are well known, have been intimately connected with the development of these two fibre-producing machines for many years past. They have reported in great detail from time to time, and in their most recent report draw attention to the fact that "seed-lint" is precisely the same material as hull fibre, but as it is recovered direct from the whole seed, seed-lint should be a cleaner, longer, and higher grade product than hull fibre, which, in fact, it is. Messrs. Clayton Beadle and Stevens point out that all they have reported as regards the industrial value of hull fibre applies *a fortiori* to seed-lint.

It has already been stated that large quantities of hull fibre have been employed in the United States in the manufacture of explosives, and it is therefore not surprising that the Director of Propellant Supplies in Great Britain should have found that seed-lint is suitable for the preparation of nitrocellulose powders.

It may also be mentioned that Messrs. Courtaulds Limited, of Coventry, the great firm of artificial silk manufacturers, have used seed-lint for the production of artificial silk on a manufacturing scale, and have found it in every way suited for this purpose.

Mr. C. F. Cross, who, it is perhaps unnecessary to say, is one of the highest authorities on cellulose, has independently examined and tested the properties of "seed-lint" for the production of cellulose acetate, and states that in this respect it fulfils the most exacting requirements.

Enough has been said to show that the industrial value of these short cotton fibres has now been amply proved and established commercially.

Method Recommended for the Recovery of these Residual Fibres.

It is well known that in ginning or linting cotton seed care has to be taken that, so far as possible, only fibres of spinnable length are taken off. In proportion as a bale of cotton contains fibres of less than a certain length, so does the value of the bale fall.

Similarly, the market value of the "linters" produced is a function of the average length and cleanliness of the "linters." If the saw-linting machine be set to lint too closely, the average length of the linters is correspondingly reduced (and incidentally the power expended increases) and the price falls. In fact, it may be said that the total amount of money realised for the product of the saw-linting machine is about the same whether a large or a small quantity of linters per ton be taken off, because the grade varies almost inversely as the quantity removed in one cut. This fact has not escaped the attention of our friends in the United States now that the industrial value of these short fibres has been brought into prominence, and in the spring of last year an interesting discussion was published in the columns of the *Cotton Oil Press* (published in Washington, D.C.), the official organ of the United States Inter-State Cotton-Seed Crushers' Association.

On account of the large quantity of residual fibres retained by American seed after ginning,

it would be impracticable for the seed-crusher to decorticate the seed just as it is received from the gin. An undue quantity of oil would be absorbed by the lint during the passage of the seed through the decorticator, and, further, the cutting action of the huller knives would be impaired. It has been customary for many years past in the United States to remove a portion of the residual fibres in a saw-linting machine prior to decortication of the seed.

These machines were originally designed, if I am correctly informed, to skim off the staple of intermediate length which had escaped the action of the gin, and as long as they are confined to this, their legitimate function, such machines perform their work in a highly efficient manner, and at a reasonable cost, so that the product obtained, though small in quantity, is of a high grade, and is readily sold at a price yielding a good profit. But if the saw-linting machine is forced either in the direction of quantity of seed per hour, or of depth of cut (which governs the quantity of linters made per ton of seed), the efficiency of the machine, both productive and mechanical, falls rapidly, and the lint-product ultimately becomes one which—to use the words of a well-known authority on cotton-seed milling in the United States—"is looked upon as a necessary evil, and is difficult to dispose of even at a price that covers the cost of production."

There is one feature about these saw-linting machines which has suggested a possible means of grading the product. To quote one of the contributors to the discussion in the *Cotton Oil Press* above alluded to, "The sharper the saw, the deeper it cuts and the darker the lint. As the saw gets duller hour by hour, the lint gets better and better. The lint coming from a freshly sharpened saw, and for several hours thereafter in gradually decreasing degree, will be dark and short. That coming from it the last few hours just before removal to the filing room will be brighter in colour and better staple. That made in between these periods will be a medium grade." (It should be mentioned that during the past year or two, when the heaviest possible yields of linters were demanded owing to war needs, the linter-saws were sometimes sharpened as often as four times in the twenty-four hours.) From this fact of experience, it was suggested that instead of mixing up the products of the linter machines, as is now the practice, the linters should be removed from each machine at the end of three intervals of time and segregated, the time intervals being left to the discretion of the mill superintendent.

In view of the fact that the blunting of the linter saws is necessarily a gradual process there will be practical difficulties in the way of adopting any such method of grading, and other difficulties will suggest themselves to the minds of those acquainted with oil-mill practice, and, in particular, with linter room methods and equipment. But in principle the suggestion is good. The saw-linting machine has a function in oil-mill economics which is a very useful and profitable one if kept within legitimate bounds. Now, the recently devised seed-defibrating machine is specially designed to begin where the saw-linter should leave off. Thus in the case of woolly cotton seed destined for decortication, the seed-defibrator can continue the work of removal of the surplus residual fibres to the extent which will leave the quantity of short fibre on the seed necessary to ensure efficiency of decortication and subsequent segregation of the meats from the hulls.

It has been seen that there already exists a machine and process whereby the remaining short fibres can be recovered from the decorticated hulls; hence, in order to obtain the best results, it would appear the part of wisdom to distribute the work of defibration judiciously between the saw-linting machine, the seed-defibrator, and the hull-defibrating process, somewhat as follows:—

Assuming the weight of residual fibres per ton of American Upland seed to be 11 per cent. of the total weight of the seed, this could be recovered by the three machines in three grades, each being the best of its kind, in the following proportions:—

	Per cent.
Saw-linting machine (high grade linters) .	2
Seed-defibrator (seed-lint)	3
Hull-defibrating process (hull-fibre) . .	6

Of course, these proportions are not like the law of the Medes and Persians. According to the character of the woolly seed employed it might be found more profitable to remove less than 2 per cent. per ton in the saw-linting machine, and more than 3 per cent. in the seed-defibrator. On the other hand, in the case of many varieties of woolly seed grown in India, it is probable that any treatment of the seed in the saw-linting machine will be superfluous, and the ginned seed may be sent straight into the seed-defibrator.

I have had experience of the defibration of upwards of 50,000 tons of the decorticated hulls of American seed, and the above distribution

of the work of defibration of woolly seed is dictated by my personal knowledge of the circumstances. At present these products would command very high prices. In pre-war times they would have realised $3\frac{1}{2}d.$ per lb., $2\frac{1}{2}d.$ per lb., and $1\frac{1}{2}d.$ per lb. respectively, thus aggregating about 45*s.* per ton (2,240 lb.) of seed. The total costs per ton of seed of the extra operations involved should not exceed about 11*s.* 6*d.*, leaving, say, about 33*s.* net added profit per ton of seed.

The Potential Value of the Indian Cotton-seed Crop.

In the spring of 1917, Sir A. D. Steel-Maitland (then Under-Secretary of State for the Colonies) delivered an address at the London School of Economics and Political Science on "Oils and Fats in the British Empire," in the course of which he stated that "the local production of cotton seed in India is very large, reaching 2,000,000 tons per annum. The quantity exported, chiefly to the United Kingdom, varies from 100,000 to 400,000 tons, a slight difference in price being sufficient to bring forward largely increased quantities."

This estimate is corroborated by Professor Dunstan, who put the Indian cotton-seed crop in 1913–14 at 2,120,000 tons. (*Bulletin* of the Imperial Institute, July–September, 1917.)

So far as any systematic utilisation of the Indian cotton-seed crop is concerned, the present situation is well summed up in an interesting and instructive paper read before the Manchester section of the Society of Chemical Industry in May, 1917, by Mr. Kapilram H. Vakil, chief consulting chemist to Messrs. Tata Sons, Limited, of Bombay. He says: "The total area under cotton in India has been of late nearly 23,000,000 acres, and the total estimated output of cotton from this acreage is 4,500,000 bales of 400 lb. each, or about 800,000 tons of cotton. From these figures the quantity of seeds produced during the year may be roughly calculated on the basis of 30 per cent. lint and 70 per cent. seeds, which amounts to 1,870,000 tons. The amount of seeds required for agricultural purposes would be, at the rate of 14 lb. per acre, about 100,000 tons, leaving about 1,750,000 tons for feeding cattle and for crushing. In 1901, when Indian seeds were first introduced into England, there were then produced in India 1,260,000 tons of seed. This huge quantity of seed was practically wasted."

Now, Mr. Vakil presumably uses the word "wasted" in the sense of "not turned to account in a manner representative of proved commercial possibilities." In this sense Mr. Vakil is right. Even to-day, owing to the fact that the cotton-seed oil industry in India has not been developed on modern lines to any appreciable extent, large quantities of cotton seed have been fed direct to cattle in India, which, undoubtedly, is about as "wasteful" a proceeding, from the point of view of national economics, as could well be imagined.

In a Consular report issued by the United States Government (Department of Commerce) on November 4th, 1918, the following reference is made to cotton-seed crushing in India:—

"India is in the same condition as was the United States forty years ago as regards the scientific utilisation of cotton seed. Except for some 250,000 tons exported to England, and for the quantity needed for sowing, the cotton seed is practically all used for fodder, at an enormous economic waste of edible oil. There was but one oil-mill in India in 1915 . . . The annual loss due to lack of a modern crushing industry in India has been estimated at Rs. 315,000,000."

This estimate seems to me to be rather a high one. Possibly it is based upon present-day prices for cotton-seed oil and cake, which, of course, cannot be expected to maintain their present level. I have gone carefully into the matter and, assuming that only 1,500,000 tons of seed per annum are potentially available in India for crushing, and that the residual fibres on such quantity are properly turned to account, the average Indian cotton-seed crop should have a market value, under pre-war trading conditions, of certainly not less than 18 to 19 crores rupees (£12,000,000 to, say, £12,500,000). After deduction of the costs and expenses of treatment (about 2 crores) this works out to a return of about 106 rupees (about £7) per ton of seed. So far as I have been able to gather, the average price of cotton seed up country in pre-war times did not exceed 45 rupees (about £3) per ton. Hence, the *nett* loss in revenue owing to the absence of a fully developed crushing industry may be put at £4 per ton of seed, or £6,000,000 per annum as a minimum figure. Doubtless, were 1,500,000 tons of cotton seed milled scientifically in India, and the products dealt with in the light of modern knowledge and experience, the *actual* nett loss in revenue would prove to be much higher than £6,000,000 per annum.

Let us now examine into the advantage to

be gained by defibrating Indian seed destined for export. We will consider two varieties, Bombay seed and Cambodia seed, which may respectively, be taken to be representative of the least woolly and the most woolly of the Indian varieties. Bombay seed retains only about 1½ per cent. of merchantable fibre worth recovering; but measurements show that after the removal of this quantity of fibre the seed bulks appreciably more closely, that is to say, a given volume will contain from 12½ per cent. to 15 per cent. more defibrated seed than undefibrated. Assuming that the defibration were carried out at the ginnery—as, of course, it ought to be—and that 5 per cent. of dirt and other foreign matter is also removed in the process of defibration, a railway truck of cleaned defibrated seed would carry about 15 per cent. more seed, and some advantage in freight charges would be obtainable on this account. The shipment sack now used would contain some 15 per cent. more seed, and as freight is paid per ton measurement – but the seed is sold in British markets per ton weight—the shipper would save some 3*s*. in the £ in ocean freight, and also something on the sacks. Produce brokers who have inspected samples of Bombay seed, cleaned and defibrated by this seed-defibrating machine, have stated that such seed would command a premium of 15*s*. per ton in British markets above prices ruling (in pre-war days) for Bombay seed as now shipped. Under conditions ruling to-day the premium would be much higher.

Cambodia seed may fairly be assumed to be on a par with American Upland, and may thus be taken to retain, say, 11 per cent. of its total weight of short lint after ginning.

This seed would probably contain the same amount of dirt and foreign matter as Bombay seed, say 5 per cent. Possibly 2 per cent. of its weight in "linters" would be recoverable by saw-linting machinery, and a further 7 per cent. of "seed-lint" in the seed-defibrating machine. This would leave about 2 per cent. of its weight of very short lint on the seed shipped, which is about the quantity found upon Egyptian (a bald) seed, and is useful in binding together the cake made and preventing it from becoming friable.

Measurements made of Uganda seed (which is similar to Cambodia) before and after defibration show that a given volume will contain about 20 per cent. more weight of defibrated seed, and London cotton-seed brokers who have inspected samples of this seed after defibration state that it would command a price within, say, 5*s*. or 10*s*. of Egyptian seed, provided, of course, that there was an equivalent in oil. From analyses which have been furnished to me by Messrs. Clayton, Beadle & Stevens, it would appear that the percentage of oil in cleaned defibrated Uganda seed should be well up to that in Egyptian seed. The average difference in price between Uganda and Egyptian in pre-war times may be taken on the average to have been about £2, so that cleaned defibrated Uganda seed should command a premium of about 30*s*. per ton over the price of such seed as shipped heretofore.

The table on page 195 indicates the additional return which should be obtained by defibrating these two varieties of Indian seed, viz., Bombay and Cambodia, prior to shipment from India to British ports. As a measure of prudence, the premium on defibrated Bombay seed is taken at 12*s*., and that on defibrated Uganda (or similar seed, such as Cambodia) at 25*s*. per ton.

If the percentage of dirt in the seed should be less than that assumed (5 per cent. of the total weight of the seed) the additional return per ton original weight of seed would be increased. It will, of course, be understood that the figures on page 195 are *exempli gratiâ*. In practice, the additional return may prove larger or smaller according to circumstances, but in any case it should be substantial.

These figures, it is perhaps needless to point out, must not be taken to indicate that a given quantity of seed could be made to produce proportionate results anywhere in India. No doubt in some localities cotton seed will continue to be fed direct to cattle because local conditions may militate against its being dealt with profitably in any other manner, just as in the United States probably 5 per cent., or more, of the cotton-seed crop is unavoidably "wasted" for similar reasons.

Further to enlarge upon this topic would carry us into details beyond the scope of this paper.

One other point may be mentioned upon which the defibration of woolly cotton seed may bear importantly, namely—

The Facilitation of the Selection of Germinable Planting Seed.

The following remarks are based upon figures supplied to me by an eminent

	Bombay Seed. 100 tons. (say 2 per cent. residual fibre)		Cambodia Seed. 100 tons. (say 11 per cent. residual fibre)	
Dirt	5 per cent.	5 tons.	5 per cent.	5 tons.
Linters	—		2 ,,	2 ,,
Seed-lint	$1\frac{1}{2}$ per cent.	$1\frac{1}{2}$ tons.	7 ,,	7 ,,
		$6\frac{1}{2}$ tons.		14 tons.
Weight shipped		$93\frac{1}{2}$,,		86 ,,
		100 tons.		100 tons.
Premium on defibrated seed in British markets	say 12*s.*		say 25*s.*	
Value as now shipped (undefibrated)	£5 per ton.		£7 per ton.	
Value realised for quantity shipped	£5 12*s.* per ton.	£ 523	£8 5*s.* per ton.	£ 709
Add net profit on sale of linters		—		25
Add net profit on sale of seed-lint		11		49
Add saving on freight owing to closer bulking (taken at $12\frac{1}{2}$ per cent. for Bombay and 20 per cent. for Uganda), and saving of £1 per ton of dirt and seed-lint		say 19		say 34
Total		£553		£817
Value of seed as now shipped	£5 per ton.	£500	£7 per ton.	£700
Net additional return		£53		£117
Net additional return per ton original weight of seed (100 tons)		10*s.* 6*d.*		£1 3*s.*

[Note.—Figures throughout refer to pre-war trading conditions.]

authority on cotton-seed products in the United States.

United States.	1912.	1913.	1914.
Crushed (official tons 2,000 lb.)	4,579,508	4,767,802	5,493,899
For fertiliser (and wasted)	1,000,000	1,000,000	1,000,000
For planting (round numbers)	587,031	602,617	752,065

The above estimate of seed for planting is based upon the generally accepted estimate of an average of one bushel (30 lb.) per acre. The acreage under cotton in the United States varies from, say, 33,000,000 acres to 38,000,000 acres.

Wherever woolly seed is produced, much seed is unavoidably wasted in planting. Cotton is planted in rows averaging about $3\frac{1}{2}$ feet apart. In some plantations this distance is wider, in others narrower. The seeds are drilled into the row as thickly as possible. They germinate irregularly, but more plants come up than can be allowed to grow. When they are two to three inches high, they are "chopped" out by negro women with hoes, leaving one good strong plant for every foot or so of the row. Thus about 12,000 plants are grown on one acre, and this, of course, involves only that number of sound germinable seeds. A bushel of average American cotton seed contains about 150,000 seeds, so that considerably less than 10 per cent. of the seeds planted actually reach effective maturity. There is thus a loss of more than 90 per cent. of the seeds planted, which, in the year 1913, would have been about 540,000 tons. This great waste is caused owing to the impossibility, practically speaking, of determining the germinating qualities of the seed on the farm due chiefly to the presence of so much lint on the seed. Moreover, the woolliness of the seed makes the distribution of the planting seed difficult and uncertain in the cotton-planting machine. Woolly seed will not run easily in a stream in any form of machine. On this count alone, bald seed would be preferable to woolly for planting,

provided, of course, that the seed is not scarified or heated in the process of removing the lint.

There is a scientific side to the question of the selection of cotton seed for planting, and among those who have occupied themselves with this matter, Dr. Lawrence Balls may be mentioned as having devoted many years of most painstaking labour to very detailed scientific investigations on a practical scale. It is nothing short of a calamity that his work should have been interrupted just when his arduous labours in this field had begun to yield exceedingly valuable results. At the present time when the air is thick with committees and commissions urging the claims of scientific effort in almost every conceivable direction, it is difficult to realise that only a few years ago there was probably no more cordially despised person in the eyes of the industrial community than the scientific man.

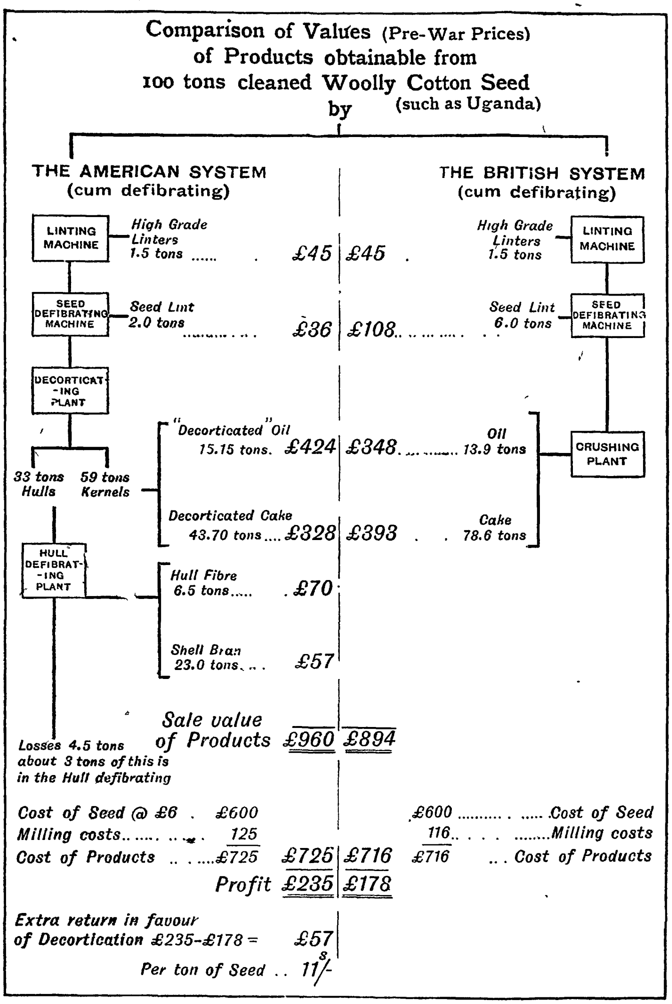


FIG. 2.

The purely scientific side of the selection of seed for planting cannot, however, be entered upon here. Moreover, it is lamentably true that—in the words of an American authority—"99 per cent. of the cotton-planters have not the skill to deal with the question, and 99 per cent. of the remainder don't know and don't care about the matter at all."

Nevertheless, it is worth while to consider the logical outcome of the defibration of planting-seed from the purely commercial point of view.

Let us suppose that the 600,000 tons of seed used for planting in the United States in 1913 had been first defibrated. There would have been produced some 12,000 tons of high grade linters worth at least £300,000. There would have been recovered some 42,000 tons of seed-lint worth at least £500,000. At a prudent estimate these commodities would have yielded a net profit in pre-war days of £520,000. Even allowing 48,000 selected germinable seeds per acre for planting (or four times the actual number of individual plants) the quantity of such seed required for planting 33,000,000 acres would amount to 132,000 tons (of 2,000 lb.). There would thus have been 414,000 tons more seed available for the oil-mills, and this, at $25 per ton, would have brought in an additional revenue to the farmer of over £2,000,000. Thus some £2,500,000 is now being literally thrown away in the United States annually.

Incidentally, the gentleman who drew my attention to these figures wrote at the same time: "I would regard it as a mathematical certainty that the planting of good germinable and plump seed, of whatever heredity, in the United States, would increase the yield of cotton per acre more than 10 per cent. One

year's crop is worth $1,000,000,000, and 10 per cent. of this is a sum of money not to be despised."

Comparison of Decorticating Woolly Seeds (cum Defibration) and Crushing Whole (cum Defibration).

The bearing of the defibration of cotton seed upon the cotton-seed oil and cake industry is of far-reaching importance, but to attempt even a brief account of this aspect of the matter would involve the writing of a treatise.

The diagram on page 196 indicates, in rough outline, the operations involved in treating woolly cotton seed of the Upland variety by the British method and by the American method, the former being supplemented by the defibration of the seed before crushing, and the latter by the partial defibration of the seed prior to decortication, and the subsequent recovery of the remaining cotton fibre from the decorticated hulls by means of the hull-defibrating machine. For purposes of comparison, fair average values under pre-war trading conditions have been adopted throughout. It will be understood, of course, that this diagram is not representative of actual present-day British and American practice respectively.

It will be seen that a substantial additional return per ton of seed should be yielded by the American-cum-defibrating method as compared with the British-cum-defibrating system.

In order more clearly to bring out the advantages of turning the residual fibres to account, when woolly cotton seed is in question, the following table has been prepared. Columns (*a*) and (*c*) represent respectively modern American and British methods. Columns (*b*) and (*d*) indicate the new products obtained by the machines referred to in this paper.

Products.	American System (decorticating the seed and crushing the meats only).				British System (crushing the seed in its entirety).			
	(*a*) Good pre-war practice.		(*b*) Result of addition of seed and hull defibration.		(*c*) Good pre-war practice.		(*d*) Result of addition of seed defibration.	
	Weight in tons.	Value.	Weight in tons.	Value.	Weight in tons.	Value.	Weight in tons.	Value.
High-grade Linters	1·50	£45	1·50	£45	1·5	£45	1·5	£45
Seed Lint	..	..	2·00	£36	..	..	6·0	£108
Oil	15·15	£424	15·15	£424	13·9	£348	13·9	£348
Cake	43·70	£328	43·70	£328	84·6	£402	78·6	£393
Hulls	35·00	£50			...	..	..	..
Hull Fibre	..	..	6·50	£70	..	..	..	..
Hull Shell	..	..	23·00	£57	..	..	..	..
	95·35		91·85		100·0		100·0	
Sale value of Products		£847		£960		£795		£894
Cost of Seed	£600		£600		£600		£600	
Milling Costs	£82	£682	£125	£725	£75	£675	£116	£716
Profit		£165		£235		£120		£178
Extra profit referable to defibrating machines (after deduction of extra costs)	......		£70		......		£58	

It will be seen that both on the American and on the British systems the value of the products should be substantially increased by turning to account the residual fibres in the manner suggested on page 192, and if—as is

probable—higher prices than those in pre-war days rule for some time to come, the *relative* advantages of decorticating and of turning the residual fibres to account should be correspondingly increased.

As indications seem to point unmistakably to a largely increased production of woolly cotton seed in the British Empire in the future, these figures are not without interest, and it is hoped that this paper, incomplete though it be, may be the means of evoking a useful discussion of the points referred to, and of many important questions bearing upon the future of the cotton-seed oil industry in the British Empire.

DISCUSSION.

Mr. D. T. Chadwick, I.C.S. (Indian Trade Commissioner), said that Mr. de Segundo's paper dealt with a process which should be of the greatest interest to India. He would not follow the author into his estimates of what were the possible total outturns of cotton-seed cake and oil in India. Whole cotton seed was the Indian farmers' favourite concentrated food for their cattle, and it would need much effort to persuade them to use cake instead. Yet, in spite of that, cotton seed was crushed for oil in India, and when prices were favourable it was also exported in considerable quantities. The author was right in saying that the presence of these short fibres on the seed was looked upon with disfavour by the export trade; not only were they a waste article, but a deleterious one owing to their causing the seed to heat in transit. The only suggestions hitherto made in India for dealing with them was to destroy them either by abrasion or by burning. Mr. de Segundo now proposed to remove them in such a way as to give them a real market value. These fibres also, when removed, could be pressed and baled. The importance of the proposed process to India's export trade was obvious, but it did not stop there. It had a direct bearing on Indian industries. Unless the prices offered for such short fibres by the artificial silk industries were so high as to tempt them to be exported, they should find a ready market among the paper-mills of India which are in need of a local supply of raw material giving readily and easily a good white paper. Another reason why the process should interest India was that undoubtedly the correct position for these machines was alongside the gins employed in removing the spinnable lint from the seed-cotton. The ideal undoubtedly was for the seed, after leaving the gins, to be conveyed, preferably automatically, to a series of these machines, which would then remove these smaller fibres so that they could be baled separately and sent to the paper-mills or other factories. The seed bulking more closely than before would go to the farmer or to the oil-mill. He wished Mr. de Segundo had seen his way to give some indications of the outturn of lint per hour and the horse-power used. The process apparently possessed great possibilities of commercial success, and was one eminently suited for Indian conditions. It was a most interesting and stimulating paper. He would only add that Mr. de Segundo had mentioned two machines, one for removing the short fibres from the seed, and one for removing the short fibres from the cotton hulls produced by decorticating the seed. It was the first of these, which had been shown at work that afternoon, that, in his opinion, was the one of most immediate interest to India. With the development of the cotton-seed crushing industry in India, the second machine, which dealt with the decorticated hulls, should come into operation, as Mr. de Segundo had given good reasons for the view that in a country in which woolly cotton seed is produced, the decorticating system possessed advantages over that of crushing the seed whole.

Mr. C. F. Cross, F.R.S., thought the author had dealt with an economic proposition in an excellent way. In regard to cellulose and cellulose products, there were three cases of squandering of natural values on a scale which was unexampled —namely, cotton, wood and coal. The author had brought forward a case for the economic utilisation of a hitherto wasted raw material, and had shown great ingenuity in carrying this through to a practical and industrial stage. What had been seen that afternoon of the performance of his seed-defibrating machine was quite sufficient to show that a fibre of very high concentration of cellulose was produced, and in the present state of the European market there was ample room for 50,000 tons a year of any fibre of that order without sensibly affecting the prices, and Mr. de Segundo's new product would constitute a very valuable addition to our national and Imperial assets.

Professor John A. Todd, in dealing with the question from the point of view of the supply of cotton, thought there were many countries in the world in which cotton could satisfactorily be grown; but the question was whether it could be made to pay in competition with other crops. One of the factors in that question was the by-products that could be realised, and he thought the by-products obtained from cotton by means of the author's machine might just turn the scale in many cases in favour of cotton. The importance of these by-products could hardly be exaggerated. The use of fibrous cellulose for artificial silk-making was one of the great possibilities of the future. Artificial silk had changed its position completely. At first it was looked upon as a luxury trade, as a substitute that people could perfectly well do without in hard times; but the position at the present time was that the world was short of textile materials of all kinds, in some cases temporarily, owing to decrease of freight, and in others, such as cotton, owing to

conditions which it would take a long time to overcome. Artificial silk was now being used in many ways as a staple raw material. For example, he had been very much impressed with the use of artificial silk in a union cloth with wool for the production of the finest dress fabrics of the kind he had ever seen. The basis for that article was a product which could be turned out by machinery from almost any fibre waste to an unlimited extent. There was practically no limit to the possibilities of artificial silk, and the author had produced an excellent raw material. If the present experiments proved to be successful, all kinds of cotton waste, and even what one would call the last rubbish of the cotton seed, would prove to be an extremely useful material. Another by-product, cotton-seed meal, would also prove to be a useful addition to our food supplies, there being unlimited possibilities in the food values of cotton[illegible] meal. It was not merely a diluent of w[illegible]; it had peculiar qualities of its own which [illegible] specially valuable if utilised in the proper wa[illegible]

Mr. J. W. Pearson (Chairman of the British Oil and Cake Mills) esteemed it a great privilege to have been invited to say a few words on the very interesting and able paper given by Mr. de Segundo. As representing the largest firm of seed-crushers in the world, he would no doubt be forgiven if he spoke only from the crushers' point of view. Out of Mr. de Segundo's several statements two principal points arose: first, the comparison of the American with the British method of crushing, and second, the application to the British trade of the Segundo defibrator. When Mr. de Segundo first approached him, some seven or eight years ago, with his then new hull-defibrating machine, he approached the British trade in the light in which the British industry was often considered by those outside, namely, by comparing it unfavourably with existing American methods. It had taken him some considerable time to impress upon Mr. de Segundo that the difference in the British method was not due to ignorance or apathy on the part of the British seed-crusher, but because he knew all there was to know about the American method and had found that his own British system was the best for Britain. Mr. de Segundo had given some tables in his paper which seemed to indicate that British crushers could make a larger profit by treating their cotton seed on the American system. He could not agree to this. Mr. de Segundo had explained that the main difference lay in the fact that while the extraction of oil was the primary essential of the business, the American did it by first separating the kernel from the shell, and the Briton did it by extracting the oil from the whole seed as it came to him. In Britain the cake-residue was obtained in the form of the whole mass together, and was sold as a concentrated food, but nevertheless one of reasonable bulk, at a price which commanded a higher figure than the American was able to obtain in the aggregate for his two products, decorticated cake and decorticated hulls. Under the British system part of the value of the process lay in the fact that in the course of manufacture an actual gain in weight was obtained. There was a little more moisture in the cake after cooking than was found in the original seed, and he was a poor crusher who did not obtain a 2 per cent. gain. As a practical crusher, he could assure those present that it was actually the fact that, under the conditions subsisting in Great Britain, the gross profit on treating the seed obtainable in Great Britain by the American system would be less than that earned on the system employed. In actual practice there was a distinct beneficial advantage in Great Britain in crushing the seed all in one mass as compared with the process of crushing the kernels alone by the American method, and it was a well-known phenomenon that with ordinary crushing machinery the material that was highest in oil content was the most difficult to manipulate. That was the reason why he suggested that the oil yield was slightly higher by the British system, and in addition that there was a slightly greater gain in weight obtained through the absorption of moisture by the lint which Mr. de Segundo was proposing to remove. The reason why there was the extra value in cake made by the English method was very largely climatic. The American cake as sent over here was very highly concentrated and very rich in nitrogen, and took its place amongst the most highly concentrated artificial foodstuffs known in the world. It was therefore used to enrich the ordinary diet of cattle. Undecorticated cotton cake in England was used as a common food, very largely as a sheep food where bulk was required, but also as a coarse cattle food. In England the quality of the grass was much richer and softer than in America and countries near the tropics. The grass in England was luscious, tender, soft, and wet, and it was necessary, particularly in the early part of the year, that something of a distinctly costive nature should be used while beasts were on the grass. Undecorticated cotton cake particularly well fitted that special purpose. British cake was used with the early grass and with the late grass, and it was on account of that particular quality that cotton cake was highly regarded, and commanded a price in England higher than its actual nutritive chemical contents might warrant. When Mr. de Segundo approached the industry first with his machine, he approached it from the American standpoint. All his arguments were met with what, in the early stages, he no doubt regarded as the obstinate stupidity and ignorance of the British crusher; but in the end he set himself to devise a machine which, working *in co-operation with* the British system, would obtain the fibre from the whole seed. The result was that he had now turned out the machine which he had demonstrated there that day, and which removed a superior quality of fibre from the seed to that obtained from the hulls, without breaking the seed up. As to the application of the machine

to the British industry, Mr. de Segundo's first design of seed-defibrating machine had been tested about three years ago in one of his company's mills with only a modicum of success. The principal drawback was that the machine then had a very small output. He had constantly urged upon Mr. de Segundo that if this were to be a seed-crusher's machine, the first essential was to obtain a large output in the minimum of floor space, and he understood that Mr. de Segundo had already considerably increased the capacity of this machine. He entirely agreed that the correct place for this machine was, as already suggested by Mr. Chadwick, alongside the original gins. Ground was less valuable and more accommodation was available, and these machines could be added to the rest of the plant so that the lint and the whole of the fibre could be taken off at the time the seed was being ginned, and only the clean seed sent over to this country for treatment in the mills. In that way an undoubted advantage in the saving of shipping space would be obtained. There was one point still to be considered, as to which he was still partly a sceptic. Mr. de Segundo had always urged upon him that by removing the fibre from the seed he must inevitably raise the value of his clean seed. In theory that appeared to be correct, because, as he had stated, the market value of black seed was very much higher in ordinary times than the value of any of the seeds of the white description, but that was not altogether because of the absence of this white lint. The higher value was in some measure due to the seed being of a different description, and a higher price was naturally paid for a higher oil content. He was not prepared to admit that the removal of the lint and the conversion of this white seed into black seed would necessarily mean a higher percentage extraction of oil. In his opinion there was no doubt that the presence of a small proportion of the lint assisted in the formation of ducts or channel ways in the meal, and consequently tended to increase the freedom with which the oil exuded from the seed. If the lint were removed he certainly admitted that the oil content in the *cleaned seed* would be greater than that which was now obtained. He had never seen his way to agree, without question, with the author's suggestion that there must *ipso facto* be an improvement in the value of the seed by defibrating it, and as a factory owner he must still remain sceptical until it was proved otherwise. The British Oil and Cake Mills, Limited, had placed at the disposal of Mr. de Segundo an up-to-date mill where his machine could be installed and a demonstration made on a commercial scale, and although he still adhered to the view that the proper place for this machine was India, he was confident that there would be no lack of the necessary initiative and the means of development as soon as the machine itself could be put to a thoroughly practical commercial test. There was, however, an almost certain profit to be made out of the lint fibre as removed by this machine, which was saleable at a price of at least £18 per ton—whereas, if left on the seed it became incorporated in the cake and realised only the price of the cake, namely, some £5 per ton, the difference showing the equivalent of 15*s*. per ton of seed, if 6 per cent. of fibre on the weight of the seed was removed. The development of the cotton-seed industry during the last hundred years, the discoveries as to the uses to which its products could be put in a thousand and one directions, and the hundreds of industries that were now interested in the several by-products, constituted one of the most marvellous romances in commercial history, and he ventured the opinion that Mr. de Segundo with this new invention had added a page of lustre to the volume.

Mr. Richard Maurice read a communication from Mr. J. E. Taylor, analytical chemist of the Therapeutic Foods Company, which stated that, as manager of a firm which manufactured diabetic breads from which carbohydrates had been extracted, he had made numerous experiments with cotton-seed flour, a product which was welcome inasmuch as with foods of that nature the main object was to increase the proteid content to the maximum consistent with palatability. That cotton-seed flour was rich in proteid matter was proved by the analysis given by the author. Firstly, it contained no starch at all—an appreciable advantage—from 54 to 56 per cent. of proteid, and about 9 per cent. fat. The digestibility of those proteids was very little less than that of those contained in wheat flour, and although it was not suggested that cotton-seed flour should altogether replace wheat flour, as an adjunct in the manufacture of bread for the treatment of diabetes and kindred complaints he felt sure it would be found invaluable. The chief objection was its colour. Diabetic folk were unquestionably very fastidious about their diet, and might be prejudiced if the colour of the bread was not altogether to their liking. He had every reason to believe that a bleaching process which was not in the least degree harmful to the most delicate digestive organs could be applied. The greater number of diabetic foods were prepared from proteids obtained from enemy countries, and everything which assisted the manufacturers to prevent industry from reverting to Germany and Austria should be regarded not only as a matter in the manufacturers' interests, but in those of the nation generally.

Dr. W. Lawrence Balls said that he had been very much impressed by the ingenuity of the machine by means of which Mr. de Segundo achieved what appeared to be the almost impossible operation of removing hairs from a cotton seed. The point that concerned him more directly was the effect of the treatment on the seed at the time of planting. So far as he could see it would make very little difference. It must be borne in mind, however, that a certain amount of hair on the seed

facilitated the absorption of water when it was lying on the surface of the ground after a shower of rain, whereas a smooth seed could not be thoroughly wetted because the wet would dry off and the waxy surface would remain unbroken, so that the seed would not germinate. Seed which had been defibrated would obviously be liable to that drawback, but probably less so than ordinary seed, such as ordinary Egyptian seed. On the other hand it was the fact that too much hair on the seed hindered germination, and on the whole, speaking from the agricultural point of view, he thought the balance probably was that the effect of the treatment would be advantageous.

Dr. H. P. Stevens said that many years ago, when the author worked on his machine for the production of the hull fibre, some investigations that he and his late partner had had the opportunity of carrying out showed that there was no doubt as to the excellence of the fibre then produced for the purpose of papermaking. With regard to the relative advantages of the American and British system of treating hulls, some years ago a company was started in London to decorticate cotton seed and produce meal on the American system, and the question arose as to what could be done with the hulls. It was found that by a certain chemica treatment it was possible to grind the hulls to an impalpable powder, and it seemed to him that there was no reason why the powdered hulls should not be incorporated with the meal to make a cake similar to the British undecorticated cotton cake, but which would possess the advantage of being more easily digested and less liable to cause trouble when fed to sheep and cattle.

Mr. de Segundo, in reply, said that it had seldom fallen to his lot to find his audience in so large a measure in agreement with him. Mr. Chadwick and Mr. Cross had inquired as to the output of the present form of seed-defibrating machine, and the cost of defibration per ton of seed. As to the output, he was hardly as yet in a position to state this with exactness, as he had not reached the limit of performance of the new type of machine exhibited for the first time that afternoon. He might say, however, that the quantity of seed treated by the small machine he had shown in operation was over seven times as great per square foot of floor space as that of the original type tested some three years ago by Mr. Pearson, and that the power consumption was less than one half. As regarded the manufacturing cost of production of the seed-lint, it would be such as would enable seed-lint to be put upon the market at a price which would compare very favourably with that of any other material yielding so high a concentration of cotton cellulose. Mr. Pearson had referred to the tables in the text of the paper, and had said that they were liable to be interpreted as meaning that British crushers would earn a larger profit if they decorticated the seed, and that he could not agree with this. The tables were not designed to convey any such impression. It was certain that if British crushers attempted to apply American methods in the milling of such cotton seed as had hitherto been obtainable in Great Britain, it would result not only in a reduced profit, but in a substantial loss. He had given in his paper two good reasons why the British crusher continued to crush cotton seed whole. One was that the varieties of cotton seed obtainable in Great Britain in the past could not be efficiently dealt with on the American system, and the other was that the presence of the shell in the cake which was sold as a food for cattle, was an advantage at certain periods of the year, particularly for feeding sheep. Mr. Pearson was a man of the widest experience in milling seeds and nuts of all kinds, and was much too alive to the best interests of his shareholders to continue to employ any process if a better one existed. Mr. de Segundo thought that Mr. Pearson had missed his real point which, briefly, was this: In a cotton-growing country where *woolly* seed was produced, then, provided that the residual fibres were recovered in a clean merchantable condition giving a high yield in cellulose, as was accomplished by these machines, the system of decortication would prove more remunerative than that of crushing the seed whole. If the cultivation of the American type of cotton were greatly extended within the Empire, woolly cotton seed would come forward for crushing in British mills until such time as shippers realised the benefits to be derived from defibrating the cotton seed in the country of origin before shipment, and he suggested that such woolly seed as might reach British crushing mills during this period could be more profitably dealt with on the decorticating-cum-defibrating system than by crushing whole. The defibrated hull could of course be employed in the manufacture of compound cake to supply the existing demand. Mr. Pearson and himself, it would appear, were really *ad idem* so far as the British seed-crusher's position was concerned, and there remained but one point to deal with, namely, the question of increased value of defibrated woolly seed as compared with undefibrated. Well, there was an old Scotch proverb, "the pruif o' the pudden is the eatin' o' it." About eighteen months ago a firm of seed brokers had sent him a parcel of 2½ tons of very woolly seed, for which they could not find a buyer at any price. This cotton seed, after having been defibrated in this machine, was sold in the market for £18 per ton. Mr. Pearson had admitted that if the lint were removed from woolly seed, the oil content in the cleaned seed would be greater than that in the uncleaned. This, after all, was but a matter of simple arithmetic, because 90 tons of defibrated seed remaining out of 100 tons, after 10 per cent. of residual fibre had been removed, would contain *the same quantity of oil* as the original 100 tons. Hence, if the seed originally analysed 20 per cent. of oil, the defibrated seed would analyse 22·22 per cent. In

other words, 100 tons of undefibrated seed would contain 20 tons of oil, and 100 tons of defibrated seed would contain 22·22 tons. He took it as a high compliment that Mr. Pearson had arranged for the installation of a plant of these machines at one of his most up-to-date mills, which surely was sufficient evidence of the progressive character of our British captains of industry. Possibly this Society which, as Lord Lamington had pointed out, had been, in a sense, a pioneer in the cotton-seed crushing industry, might hear something more about these machines at a future date.

The Chairman (the Right Hon. the Lord Lamington), in proposing a vote of thanks to the author for his interesting paper, thought the striking feature of the discussion was that the paper should have met with such a general approval from the various experts who had spoken. There had been no strong adverse criticisms, but a few points had been raised which the author had satisfactorily cleared up. He hoped the process the author had invented would be found of practical value, particularly from the point of view of the development and welfare of our Indian Empire. Another satisfactory feature of the discussion was that, while British manufacturers were supposed by many people to be ignorant and obstinate, it was very evident, from what had been said, that that was not the nature of the manufacturers concerned with the industry in question. He had been very pleased to preside on the occasion when a paper of such interest and practical value had been contributed by a very old friend of his.

Mr. W. H. Pinnock (of Messrs. Pinnock Bros.) writes:—The value of cotton seed to the seed-crusher is primarily dependentupon the percentage weight of oil that can economically be expressed in the hydraulic presses and also upon the character of the cake produced—*i.e.* the residue after the oil has been expressed. The cake is almost exclusively marketed as a foodstuff for cattle. The presence of much cotton fibre on the seed is prejudicial to the value of the seed, because, firstly, it absorbs a certain amount of oil expressed from the seed, and, secondly, it detracts not only from the appearance, but also from the nutritive value of the cake on account of the lint being non-digestible and possessing practically no nutritive properties. In normal times the average difference in the market price of Egyptian seed (which is nearly bald seed) and Uganda seed (which is a very woolly seed) was about 35*s.* to 40*s.* per ton in favour of Egyptian. Egyptian cake also commands a higher price than that obtained from woolly varieties of seed. At the present time, owing to conditions brought about by the war, Egyptian seed is selling at a much higher difference in price above Uganda and other woolly varieties. Mr. de Segundo has given me several opportunities of inspecting Uganda seed defibrated in his machine. The defibrated seed had very little fibre left on it, and showed no signs of maltreatment. In my opinion, it should certainly command the price of Egyptian seed within, say, 5*s.* or 10*s.* per ton, provided, of course, that there is the equivalent in oil. It might safely be assumed that such defibrated Uganda seed would sell for 20*s.* per ton more than the undefibrated as now shipped.

Mr. Erwin W. Thompson (an American expert in cotton-seed products, who was commissioned some years ago by the United States Government to study the cotton-seed industry in Europe) writes:—Mr. de Segundo has described in his paper a new and rational system for obtaining all the residual fibres in a good clean merchantable condition; and if this system were applied in practice—and I see no reason why this should not be done now that the war had ended—it would be epoch-making in American oil-milling. If, as would appear probable, the extension of the cultivation of American type cotton in India is to be one of the events of the immediate future, the two machines described by Mr. de Segundo should play a very important part in turning to profitable account the concomitant seed, not only in the production of oil and cake, but in improving the condition of the seed for export. The treatment of the seed could now be started in India under favourable conditions based upon American experience in decorticating, and in combination with these latest inventions for the recovery of residual fibres. The world's demand for oils and fats, which was growing rapidly before the war, and has been greatly intensified as a consequence thereof, is not likely to be very seriously affected by the termination of hostilities, and this should be an additional factor in speeding up the development of the cotton-seed oil industry in India, particularly in view of the unquestionably large unrealised value of the Indian seed crop, as to which I think Mr. de Segundo's estimate appears to err on the safe side.

OBITUARY.

William Charlton.—Mr. William Charlton, who was elected a Life Fellow of the Society in 1900, died on December 20th, in his eighty-first year. Born in Manchester, the whole of his business life of over fifty years was spent with the Ashbury Railway and Carriage Company, Openshaw, Manchester. He was one of the oldest magistrates of Manchester, and up to the time of his death took a deep interest in public matters. A keen student of numismatics, he wrote various articles on Card Money, Leather Currency, Touch Pieces, and Maundy Observances. He belonged to the British Numismatic Society and the Lancashire and Cheshire Antiquarian Society.

GENERAL NOTES.

RUSSIAN SCYTHES.—Before the war, says the *Engineer*, Russia used 6,000,000 scythes annually, of which about half were for Siberia. About 4,500,000 were imported, and the rest manufactured in the country. Of the imported scythes, those from Austria were most in demand, because of their light weight and cheapness. At present hardly any scythes are to be found in Russia, the native industry being at a standstill and the importation closed. Before the war Russian scythes retailed for one rouble each, and Swedish scythes for about two roubles, but recently Swedish scythes have fetched from 15 to 20 roubles in Russia.

GROWING COAL-PRODUCTION OF HOLLAND.—According to the *Allgemeine Handelsblad*, the whole production of coal in Holland has considerably increased since the beginning of the war. It now appears that Holland can, though with some difficulty, provide herself with fuel without having recourse to imported coal. Before the war, about 7 million tons a year were required for Dutch consumption. Of this quantity the Limburg mines produced at the most a third. During the war production increased by 270 tons a month. The output of brown coal has largely increased. Of peat there was produced in a year the equivalent of 350,000 tons of coal. The use of this fuel is rapidly growing.

OIL-WELL SINKING.—An oil well has been sunk in the Californian fields to the depth of 2,125 ft. in twelve and a half days by the rotary drill, the hole beginning with a 17½-inch diameter. In one single day, according to the *Petroleum Review*, no less than 680 ft. of substrata were pierced, while the daily average was 170 ft. In every branch of engineering the last decade has seen enormous strides, but in none has this progress been more pronounced than in oilfield operations. The days when it frequently took twelve months—and much longer sometimes—to get a well down to the oil are fortunately passed, thanks to the now general adoption of the rotary system of drilling.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

FEBRUARY 19.—JOHN FRANCIS CROWLEY, D.Sc., M.I.E.E., "The Use of Electricity in Agriculture in Germany." SIR JOHN F. C. SNELL, M.Inst.C.E., will preside.

FEBRUARY 26.—W. L. HICHENS (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry." W. A. APPLETON, C.B.E., Secretary, General Federation of Trade Unions, will preside.

MARCH 5.—B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present." PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, will preside.

MARCH 12.—WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

MARCH 19.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

MARCH 26.—SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

APRIL 2.—W. NORMAN BOASE, "Flax."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

MARCH 4.—W. R. GOURLAY, M.A., C.I.E., I.C.S., "The Need for a History of Bengal."

MARCH 13.—D. T. CHADWICK, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission."

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

FEBRUARY 25.—EDWARD J. DUVEEN, Fellow of the Royal Statistical Society, "Key Industries." W. A. S. HEWINS, M.A., late Under-Secretary of State for the Colonies, will preside.

MARCH 4.—PROFESSOR JOHN CUNNINGHAM MCLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

MAY 27.—SIR EDWARD DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced:—

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

J. N. SPENCER WILLIAMS, "The Hawaiian Islands and their Industries."

JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

LEONARD ERSKINE HILL, M.B., F.R.S., "Housing and Infant Mortality."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

J. A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

Syllabus.

LECTURE II.—FEBRUARY 17.—The transmission of long electromagnetic waves over sea and land—Penetration of high-frequency currents into conductors—The attenuation of radiotelegraphic waves—Diffraction of such waves round the earth—Effects of the atmosphere—Long-distance stations.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." Three Lectures.

March 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEBRUARY 17 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Dr. J. A. Fleming, "Scientific Problems of Electric Wave Telegraphy." (Lecture II.)

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Major-General Sir George K. Scott-Moncrieff, "The Personal Influence of Great Commanders in the Past."

Sanitary Engineers, Institute of, Caxton Hall, Westminster, S.W., 7.30 p.m. Address by the President.

Geographical Society, Kensington-gore, W., 5 p.m. Commander H. D. Warbury, "The Admiralty Tide Tables and North Sea Tidal Predictions."

TUESDAY, FEBRUARY 18...Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Mr. M. Summers, "The Financing of Oilfields."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Captain M. Greenwood, "Problem of Industrial Organisation."

Royal Institution, Albemarle-street, W., 3 p.m. Captain G. P. Thomson, "The Development of Aeroplanes in the Great War." (Lecture I.)

British Women's Patriotic League, South Lodge, Rutland-gate, S.W., 3 p.m. Miss M. Brodrick, "Egypt and the Sudan."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Mr. R. I. Pocock, "On the External Characters of the Existing Chevrotains." 2. Mr. K. M. Smith, "A Comparative Study of certain Sense-Organs in the Antennæ and Palpi of Diptera."

Secretaries' Association, Winchester House, Old Broad-street, E.C., 7.15 p.m. Mr. E. W. Mundy, "Some Experiments in Labour Co-Partnership."

WEDNESDAY, FEBRUARY 19...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. J. F. Crowley, "The Use of Electricity in Agriculture in Germany."

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Dr. S. Chapman, "The Lunar Tide in the Earth's Atmosphere." 2. Mr. M. Christy, "The Gunfire on the Continent during 1918: its Audibility at Chignal St. James, near Chelmsford."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Mr. P. C. Varrier-Jones, "The Future of the Tuberculosis Problem."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5 p.m. Mr. E. Gosse, "Some Aspects of Literature in France during the War."

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, E.C., 4.30 p.m. Mr. J. R. Clynes, "The Responsibility of Trade Unions in Relation to Industry."

Aëronautical Society, Central Hall, Westminster, S.W., 8 p.m. Mr. C. Grahame White, "Civil Aerial Transport: is it Practicable, is it Safe, and is it Profitable?"

THURSDAY, FEBRUARY 20...Britain and India, 7, Southampton-street, High Holborn, W.C., 3 p.m. Mr. A. Yusuf Ali, "Modern Indian Poetry."

Royal Society, Burlington House, W., 4.30 p.m.

Chemical Society, Burlington House, W., 8 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. C. E. Salmon, "Drawings of British Orchids and Sea-Anemones, by Mr. T. A. Stephenson." 2. Mr. R. H. Burne, "Specimens of Sound-producing Organs in Invertebrates and Fishes."

Royal Institution, Albemarle-street, W., 3 p.m. Professor H. M. Lefroy, "Insect Enemies of our Food Supplies." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.30 p.m. Mr. J. E. Barnard, "Demonstration of Photomicrography."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. G. L. Addenbrooke, "Dialectrics in Electric Fields."

FRIDAY, FEBRUARY 21 ... Poetry Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m. Countess of Warwick, "The Democratic Influence of Poetry."

Royal Institution, Albemarle-street, W., 5.30 p.m. Mr. A. T. Hare, "Clock Escapements."

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m.

SATURDAY, FEBRUARY 22...Royal Institution, Albemarle-street, W., 3 p.m. Hon. J. W. Fortescue, "The Empire's Share in England's Wars — Western Empire." (Lecture I.)

Chromatics, International College of, Caxton Hall, Westminster, S.W., 3 p.m. Mr. E. Russell, "Vibration and Colour."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—February 14, 1919.

No. 3457. FEBRUARY 21, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2,

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,457. VOL. LXVII.

FRIDAY, FEBRUARY 21, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 24th, at 4.30 p.m. (Cantor Lecture.) J. A. FLEMING, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, London, "Scientific Problems of Electric Wave Telegraphy." (Lecture III.)

TUESDAY, FEBRUARY 25th, at 4.30 p.m. (Colonial Section.) EDWARD J. DUVEEN, Fellow of the Royal Statistical Society, "Key Industries and Imperial Resources." W. A. S. HEWINS, late Under-Secretary of State for the Colonies, will preside.

WEDNESDAY, FEBRUARY 26th, at 4.30 p.m. (Ordinary Meeting.) W. L. HICHENS (Chairman, Messrs. Cammell Laird & Co., Ltd.), "The Wage Problem in Industry." W. A. APPLETON, C.B.E., Secretary, General Federation of Trade Unions, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On Monday afternoon, February 17th, PROFESSOR J. A. FLEMING, D.Sc., F.R.S., delivered the second lecture of his course on "Scientific Problems of Electric Wave Telegraphy."

The lectures will be published in the *Journal* during the summer recess.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 19th, 1919; SIR WILLIAM FLETCHER BARRETT, F.R.S., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Benn, Ernest John Pickstone, C.B.E., Oxted, Surrey.
Billings, A. W. K., Barcelona, Spain.
Dewdney, William Gill, Derby.
Hargreaves, John William, Alderley Edge, Cheshire.
Johnstone, David Edward, Leicester.
Spencer, Douglas, B.A., Lieut. R.A.O.C., St. Ives, Hunts.
Tucker, William Edward, London.
Walker, Arthur, Whitehaven.

The following candidates were balloted for and duly elected Fellows of the Society:—

Burford, H. G., London.
Day, Bernard I., Derby.
Evans, Daniel, Swansea.
Evans, Edward Victor, F.I.C., London.
Eyre, Vice-Admiral Francis G., R.N., London.
Lewis, Robert Thomas, B.A., London.
Perry, John J. Benedict, London.
Phillips, Hon. Nelson, Austin, Texas, U.S.A.
Pomeroy, Laurence Henry, M.I.Mech.E., London.
Rowbotham, William Johnson, Croydon.
Stewart, Patrick Archibald, Bombay, India.
Walton, Eric Bell, London.
Wood, William, F.R.Hist.S., Polperro, Cornwall.
Younger, John, Washington, D.C., U.S.A.

A paper on "The Use of Electricity in Agriculture in Germany" was read by JOHN FRANCIS CROWLEY, D.Sc., M.I.E.E.

The paper and discussion will be published in a subsequent number of the *Journal.*

EXAMINATIONS FOR PRISONERS OF WAR AND INTERNED CIVILIANS.

When proposals were first made for providing educational facilities for British prisoners of war and civilians interned in Germany and Holland, the Society offered to arrange for the admission to its examinations of such men if a practicable scheme could be devised. The obvious difficulty was to secure the transmission of examination papers without the risk of their being seen before the holding of the examinations in this country, if they were to be held simultaneously here and abroad, and also without the chance of candidates abroad getting access to the papers if the foreign examinations were to be held at a later date.

Eventually, with the help of the Board of Education and of the Foreign Office, satisfactory conditions were assured, examination centres were established in 1916 at Ruhleben and at Groningen,

and these examinations were held in March and May of that year, under similar conditions and with the same papers as at the Society's regular examinations.

In 1917 and 1918 centres were also formed at Chateau d'Oex and at Mürren. In the first year 75 papers were worked, in the second 135, and in the third year 293. Speaking generally, the standard attained in these examinations was distinctly high, some of the papers being of remarkable excellence. No fees were charged by the Society to these candidates. That the efforts of the Society to assist prisoners of war and interned men were appreciated by them is shown by the following letter from Sir Alfred T. Davies, K.B.E., C.B., Chairman and Hon. Director of the British Prisoners of War Book Scheme:—

Victoria and Albert Museum,
South Kensington, London, S.W.
January 28th, 1919.

Dear Sir,

I cannot allow the recent signing of the certificates, which brings to a close the work which this organisation has been able to do on behalf of your Society, to pass without giving some expression to the gratification generally felt among the prisoners and their friends, at the smooth and successful working of the arrangements which your Society's interest and active co-operation made it possible for us to carry into effect on behalf of the interned men.

It has, I am sure, been as gratifying to your committee, as it has been to mine, to witness the splendid response which the "student captives" made to the efforts put forth on their behalf. I trust therefore that the work in which your Society co-operated with us during the war may be regarded as not the least useful of its many activities during that time.

I am,
Yours faithfully,
Alfred T. Davies.

The Secretary,
Royal Society of Arts.

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

Wednesday, February 12th, 1919; the Most Hon. the Marquess of Crewe, K.G., in the chair.

The paper read was—

THE GOVERNMENT AND THE ORGANISATION OF SCIENTIFIC RESEARCH.

By Sir Frank Heath, K.C.B.,
Secretary, Department of Scientific and Industrial Research.

The story that I have to tell this afternoon is the tale of a great adventure—one of the adventures of the great war. It was not undertaken as part of the campaign for victory in the field, but in order to help us to win the peace, a campaign now beginning and likely to be scarcely less difficult, though not as catastrophic, as the trials from which we have emerged. It was an adventure upon which the Government embarked in the summer of 1915, because, like all true adventures, it was an act of faith. The general direction of advance had been thought out, but the road was still to make and the result was as yet invisible. The problem the Government set itself was the encouragement and organisation of scientific research by direct State action. An experiment such as no country had ever attempted was undertaken by a people which, in some respects, is the most conservative in the world. We are not a nation with a finished theory of the functions and powers of government, and in that we are fortunate, for when the pressure of need arises we are willing to take courses which a more philosophical race would shun. Our enemies, whose political theory was worked out to the last detail, in confident contempt for the human nature with which it juggled, never dreamt of attempting the organisation of research by direct action of the State. They were more systematic, and, to do them justice, more zealous in their pursuit of science than any other nation. They could rely upon the effects of their highly organised State-regulated system of education. But had they found themselves in our shoes they would have discovered many excellent arguments to show the futility of attempting to organise research by State action. It would, indeed, have been an impossibility for the State as the Germans conceived it. Humboldt, in his famous unfinished memorandum to the Berlin Academy of Science, remarks: "The State must never forget that the achievement is not the State's nor ever can be; it must remember that whenever the State seeks to interfere, its action is always a hindrance; it must be content to realise that the work will proceed far better without it."

Humboldt was thinking of pure research—research, that is, in Pure Science and in learning of all kinds. It is clear, from all his remarks, that what we may call research in Applied Science for the purposes of industry and the practical convenience or well-being of life was not in his mind. But it is worth while, before I go on to explain what has been done by the Government in this country during the last few years, to say something in expla-

nation both of what is meant by "research" throughout this paper and something about the research worker and his manner of work.

Research is a term which has been very much on our lips recently, and, as is usual in cases of this kind, it is by no means always used in one sense. The Patent Office speak of a research into the terms of previous patents, by which they mean making a search for already known and recorded facts; and the word is similarly used in many cases where the sole activity is the seeking out, the collection and collation of existing knowledge with a view to some definite course of action. Strictly speaking, this kind of work would be more properly described as a "search" than a "rēsearch." At any rate it is not the sort of work with which I am concerned this afternoon. Before research in its strict sense can begin it may be necessary to make a search for facts already known and recorded, but forgotten or overlooked. Such action is of the same preliminary kind as seeking for paper and ink and pens before beginning to write; but it is no more research in the strict scientific sense than the collection of pens, ink and paper is authorship. In the meaning of the term as I am using it here research means the creation of new knowledge. It is an actual extension of the powers and capacity of man in relation to the world in which he lives, and the extension which comes from the systematic work of the original mind upon material already to hand often takes place in a direction quite different from that which is anticipated when the worker begins his labours. That is the reason for comparing research to "the wind which bloweth whither it listeth." Discoverers, in describing the history of important discoveries, have told us over and over again of this fact—a fact so frequent and pronounced that in some cases it may almost be said that a worker has blundered upon a new truth. It is not extraordinary, because the excursions of the researcher are always into a new and unmapped country, and no man can tell until he reaches it what the lie of the land is. The more concrete the field of science the more true will this be found to be. It is not surprising, in these circumstances, that the researcher himself should plead for freedom, and maintain, indeed, that without it his usefulness is lost. That is the central idea of Humboldt's thesis. That is why, in his view, the State must do damage by interference, and, indeed, if the State interferes with the natural processes of research work it *can* only do harm. In a sense the true research worker is an anarchist. He can recognise no laws of procedure but those of his own science and of his own method of attack. These are severe enough, and they can tolerate no external action which seeks to place him in blinkers and to force him to run at the discretion of men who cannot see with his eyes. The great question that is to be solved is whether it is possible, under these conditions, for the State to take action which will stimulate research without interfering with it when we mean by "research" nothing but the creation of new knowledge; and whether, in the application of new knowledge to specific problems which the State in one or other of its capacities seeks to have solved, it can do anything effective towards the organisation of the attack upon these problems. This second type of research does not call for the same degree of originality as the creation of new knowledge; but on the one hand it cannot proceed without the assistance of pure research, and on the other it is constantly revealing gaps in human knowledge which call for investigation by the pure researcher. Moreover, though much of the work in applied science is less fundamental in character, it is also, because of the large number of factors which are involved, far more complicated, and it calls for team work among researchers in an ever growing degree. But you cannot have team work without organisation. To repeat my question again: Is it possible for the State, on the one hand, to *encourage* pure research, and on the other to *organise* applied research?

This, then, was the adventure. I need not spend time here in explaining why something had to be done. You know the difficulties with which we were faced. Important raw materials under enemy control, semi-manufactured products of vital importance made only by them, finished articles essential to our staple industries or to our fighting services drawn almost entirely from enemy sources—you know the list, and you know something of the brilliant efforts made in our emergency to supply what was missing. We have submitted to State action with a vengeance. But the Government realised that emergency measures could not offer a lasting cure for our shortcomings. An attempt must be made to organise for peace. What did they do? The traditional way of dealing with a problem of this kind is to appoint a Royal Commission of distinguished persons to study the question and recommend the action to be taken. But

wise men can seldom agree to appear before the public with exactly the same answers to a question, and if the wise men disagree it becomes harder than ever to decide what should be done. Besides, time will have passed, and the problem may not seem any longer so urgent, because other problems have arisen which are clamouring for solution. Moreover, the wise men are not made responsible for carrying their advice into effect. Before anything can be done they have disappeared from the scene, and this little omission encourages argument and theory. So the Government appointed a Commission to act as permanent advisers to a responsible Minister. The Minister selected was the Lord President of the Council, because it was realised that if research was to be organised effectively, it must cover not only the whole United Kingdom, but be able to co-operate easily with possible developments of a like kind in other parts of the Empire. It was also clear that if the Government was to obtain the co-operation of the industries in regard to research, the department concerned should be free from any suspicion of being concerned either in their regulation or in commercial dealings with them. The Minister responsible should accordingly be unconnected with any administrative department of State. These considerations led naturally to the selection of the Lord President, for the Privy Council is the only department which has relations with the whole Empire, and which is free from administrative responsibilities. Parliament voted the Minister, or rather a Committee of the Privy Council of which he was Chairman, a sum of money to spend on the encouragement and organisation of scientific research — not a fixed sum, but an annual vote susceptible of increase. By an Order in Council, all proposals for spending money upon these purposes stand referred to the permanent commission which is called the Advisory Council for Scientific and Industrial Research. And the Advisory Council can initiate proposals of their own. It was a small but most significant change in the traditional procedure. The idea of making the Commission permanent was not new. There have been a good many permanent advisory committees to Government departments. The provision for changing the *personnel* from time to time is not new. The selection of a small body of men specially qualified to deal with the subject in hand is not new. The novel feature was the delegation of the responsibility for thinking out a policy to a permanent body of experts who are not Civil servants, and making this expert body an integral part of the machine by giving them the services of the permanent staff of the department, and keeping them continually informed of every departmental procedure. This was ensured by providing them with an administrative chairman who has devoted his whole time to the work, and with a secretariat which includes the heads (instead of the junior members) of the administrative staff. In a word, the Minister, instead of relying upon his officials for advice (whether technical or administrative), supplemented by such occasional guidance upon particular questions as he might refer to temporary Royal Commissions or to permanent Advisory Committees, placed all his technical advice in commission, and entrusted it to a body of seven independent and distinguished men of science, the majority of whom were also large industrialists. The result of this experiment has been most interesting. The general policy of the Minister and of the Government has been worked out, not by the official, but by the Advisory Council. The Council has watched the effects of the action it has recommended and has gradually built up a method of procedure consonant with the original intention of the Government. Stated in its simplest terms, the intention of the Government in the Order in Council of July 28th, 1915, was to delegate to independent experts the duty of devising the methods by which scientific and industrial research should be encouraged and developed. The Advisory Council, as we shall see, have carried this principle through in all the proposals which they have made. The Government had reached the conclusion, before they issued the Order in Council establishing the new organisation, that action was needed in three main directions. In the first place research was needed in a number of directions hitherto neglected; secondly, it would be necessary to establish new institutions or to develop existing institutions for the scientific study of problems affecting particular industries and trades. And finally it was clear that the number of trained research workers in the country was inadequate to our needs. The information possessed by the Board of Education was clear on this point, and had led the President, Mr. Joseph Pease (now Lord Gainford), to urge the establishment of the new organisation which your Lordship later set up as an independent department. All these three main lines of action were mentioned in

the original Order in Council, and proposals in regard to them stood referred to the Advisory Council. How did the Council proceed? They began as an interim measure by recommending the Minister to assist a number of researches conducted by scientific and professional societies which were languishing as a result of the war, and they also recommended grants to the National Physical Laboratory for an urgent research into the methods of manufacturing optical glass, and to a committee at the Central School of Pottery at Stoke-on-Trent for research into the manufacture of hard porcelain from British materials. This research has had most successful and promising results. Meantime the Council have gradually and steadily worked out, in consultation with university professors and teachers in technical schools, with the leaders in many of our principal industries, and with each of the Government Departments, a systematic procedure along the whole front, which has not only commended itself to the responsible Minister and to the Government of the day, but has been adopted or is being adopted by each of the self-governing Dominions with variations suited to local conditions, and by three at least of our Allies (America, France, and Japan).

I will divide the field of work into the three main divisions already indicated and will deal with them, for convenience, in the following order: (i) The encouragement of research workers; (ii) The organisation of research by industries, and (iii) The organisation of national research.

In dealing with each of these matters, the policy advocated by the Advisory Council and adopted by the Minister has been that laid down by the Government when the Department was founded, viz., the delegation of responsibility for each kind of service to the expert within the limits imposed by the ultimate responsibility of the Minister to Parliament, and of the Accounting Officer to the Controller and Auditor General.

The Encouragement of Research Workers.

The Advisory Council confirmed at an early stage the fears of a shortage in the numbers of trained research workers. The Consultative Committee of the Board of Education had reported in 1916 on the need for enlarging the output of our universities, and more recently the Prime Minister's Committee on the Teaching of Science, under the Chairmanship of the President of the Royal Society, has urged "that a large increase in the number of students passing through our universities is a matter of great national importance." The large plans recommended by the Advisory Council for the extension of research work will increase the demand for trained workers already inadequate for existing needs. The Research Department cannot directly ensure a larger entry to the universities and technical colleges, or assist young men and women during their undergraduate period, but it has already done something to help those who have acquired enough knowledge to begin research or who have shown capacity for original investigation. During the academic year 1916–17, a sum of over £3,500 was spent in this way, in spite of the continued withdrawal of young men for military service. In 1917–18, the expenditure rose to £7,500 and during the current year to £10,000. Now that men are returning in large numbers from the fighting services to the colleges and universities it is anticipated that over £30,000 can usefully be expended on this service during next academic year. The method of procedure adopted by the Advisory Council is as follows: In the first place, there are no scholarships or fellowships. The grants are not honorific awards carrying titles and encouraging the competitive instinct. The amount of the grant is determined within wide limits by the circumstances of each individual case. In the next place the applications are made upon the personal responsibility of the head of the department in the institution to which the worker is attached; or, if the applicant is a private worker, upon the personal responsibility of a man of scientific standing who vouches for the case and speaks as to the circumstances. Careful records are kept of the performances of workers recommended by professors and others, and the value of their recommendations is assessed accordingly. It has been found that this delegation of responsibility has worked well, much better indeed than the practice of leaving recommendations to boards of studies or to the university in its corporate capacity. And naturally so, for no one knows a student or worker so well as the man with whom he has worked. Each application comes before a Committee of the Advisory Council, and they make the award after consultation in particular cases with carefully chosen referees outside the Department. The grants made are of four kinds: (i) Maintenance grants to students to enable them to be trained in methods of research; these grants are made for a year

but may be renewed for a second year. (ii) Grants to independent research workers devoting their whole time to research, whether in pure or applied science; these grants are also made for a year, and may be renewed for a further four years. (iii) Grants to a teacher engaged on research to enable him to employ a suitable assistant to help him in his research, but not in his teaching. (iv) Grants in special cases to a worker investigating some new branch of science to enable a research lectureship to be established in a university, pending the provision of a suitable endowment from other sources. The Department has a close working agreement with the Royal Society, who administer a special Government fund for aiding research workers, under which the two bodies work in concert, keep each other fully informed of the cases that come before them, and refer to the other those applications which appear to be more suitable for their consideration.

The Organisation of Industrial Research.

The second branch of the work deals with the encouragement of research in the industries. The Advisory Council recognised that many of our industries were making less use of science than was desirable, or indeed necessary, if they were to survive. But they realised that there were many causes for this. They refused to endorse the easy cry that manufacturers were too ignorant or too indolent to make use of scientific men. This may be one factor in some cases, but it is by no means the whole story. The Council attempted to analyse the position in their first annual report, and I need not repeat the analysis here. It will suffice to say that the relatively small size of the majority of British firms, the shortage of well-trained researchers and even of routine workers in science, and the lack of mutual understanding between the universities and the industries, were some of the difficulties in the road. The Council reached the conclusion that any safe advance must be made by the industries themselves, that the most hopeful means was co-operative action by the firms in each industry, and the best the Government could do was to encourage co-operation, while leaving the immediate responsibility to those who presumably knew most about the conditions of the industry, *i.e.* to the manufacturers themselves. Thus the scheme for co-operative research associations came into being. These associations are limited liability companies working without profit and with a nominal guarantee from their members in place of shares. The members of each association make an annual subscription usually, proportionate to the size of their business, towards the income of the association, and when the memorandum and articles of the association have been approved by the Department and a licence has been issued by the Board of Trade, the Board of Inland Revenue recognises the subscriptions of the members as "business costs," *i.e.* as free from income tax and excess profits duties. If, in the opinion of the Department, further help is needed, it will make an annual grant-in-aid to the association for a period of five years. This grant is in the first instance usually pound for pound, but the average over the whole five years will in most cases be less than this. The intention is to give the new associations an impetus over a period sufficiently long to enable them to prove the value of research. After that it is anticipated that they will need no encouragement to continue the good work.

The Department acts as a clearing-house of information for the associations, and gives all the assistance and advice in its power, whether the association is in receipt of a grant or not. The association has full control of its own income, whether from Government or from its members, and all the results of research are the sole property of the association held in trust for its members. The Department asks to be kept informed, acts as the go-between when an association seeks to sell its results to another industry or association, and reserves the power to prohibit the communication of results to a foreign body or person. But this is the limit of Government interference. The Advisory Council laid stress upon the representation of science as well as capital and management on the board of directors, and they think it desirable that there should be some representation, if possible, of skilled labour. They also lay great stress upon the appointment in each case of a responsible technical officer as director of research, in order to ensure the unity of direction which is as necessary in research as in the battlefield. Two other important points of detail should be mentioned. The scheme of the Advisory Council contemplates that the associations should be limited in each case to those firms in an industry or in a group of closely related industries whose interests are sufficiently homogeneous to induce them to pool their resources for the purposes of research. It will

not usually be feasible for both producers and users to combine in a single association unless, as in the case of cotton, the producers and users are so intimately related that the processes of each immediately affect the whole business of the other. The various non-ferrous metal trades can combine without difficulty. The different branches of the internal-combustion engine trade cannot. The problems of the aeroplane engine and the heavy Diesel motor are at present too remote from each other.

The second point is that the scheme contemplates the establishment of one association of each kind for the whole United Kingdom—not a series of local associations. Experience has shown that a number of local associations in the same industry would raise questions which would inevitably lead to Government interference, and that the number of competent research workers, and especially men fitted to be directors, is far too small to allow of this procedure. A single national association avoids this danger and has the important advantage of commanding larger resources as well as wider experience. On the other hand, where an industry is widely distributed over the three kingdoms provision is made for local branches and committees with large scientific autonomy, so as to allow the research undertaken to correspond with the variety of problems arising from local differences in material or processes or types of product.

That is the scheme in barest outline. There are four associations already at work, fifteen more are just coming into existence, and another eleven are in the earlier stages of formation—in all some thirty. You will realise that great elasticity in financial arrangement was necessary to allow the Government to make agreements suited to the varying conditions of the many industries of the country, and that it was desirable to give an indication from the outset that the grants made would presumably cease after a period of some five years. Accordingly the Advisory Council recommended the establishment of a special limited fund for this purpose, and you, my lord, induced the then Chancellor of the Exchequer to ask Parliament for a fund of a million sterling to be spent, both capital and income, in aiding approved research associations. The fund is held by the Imperial Trust for the Encouragement of Scientific and Industrial Research, a body of seven Cabinet Ministers to whom a Royal Charter has been granted to enable them to hold this and other property for the purposes of the Department.

The Organisation of National Research.

We may now turn to the third section of the field—which I have spoken of as the organisation of National Research. You will have noticed that all the work already described is national in a sense, but it is work which the Advisory Council realised the Department had better delegate to authorities not itself. There remains a growing body of work which for one reason or another the Government must do itself, and this is what is meant by the phrase "National Research." The work in question may be divided into three subheads. Here again it will be seen that, leaving aside the function of intelligence which is a matter of orderly collection, collation and distribution by competent officers acting in general conformity with the directions of the Advisory Council itself, the policy is one of delegation to persons specially qualified by their knowledge and experience to do the work in hand, with great freedom to initiate and carry out a scheme of work which they themselves have devised.

I.—*A Clearing House of Information.*

I have already referred incidentally to the function of the Department as a clearing-house of information for the Industrial Research Associations. It similarly acts as a clearing-house for all the research organisations and workers with which it is officially connected. But it confines itself to this. The Council has been urged from many directions during the last two years to establish or aid in establishing a great central bureau of scientific and technical knowledge to which all and sundry might come for information from all the world over, which bears upon any conceivable point of scientific or technical interest. The proposal has been most carefully examined and as decisively rejected. Such a bureau, which would be many times larger than the Institut Solvay at Brussels, would need the services of hundreds of scientific men and linguists. Even if its information could, at great expense, be kept moderately up to date, it would necessarily be in arrear of the knowledge of any scientific worker who is abreast of the literature of his own subject, and since it would be prepared by persons not themselves actively engaged in research or in industry would in many cases at least omit details of importance to one or other line of advance. For a detail of subordinate importance to one worker may be vital to the interests of another.

On the other hand, the workers of the

research associations, the research boards, and research committees working officially under the Department will often be doing confidential work of great interest and importance to each other, and if there is not some central clearing-house the rate of advance will be much slower than it need be. This service the Department is undertaking, and it is likely, even when thus narrowly defined, to be a fairly big business. Moreover, the Department is slowly constructing a confidential register of research workers and their work for the benefit of the different organisations related to it, and now that the great war services are being curtailed, an inventory of scientific apparatus and machinery of which the Government is anxious to dispose. It is also slowly forming a technical library, and hopes that this library, as well as a common room, may be used by officers and directors of the research associations for meeting each other, and discussing with officers of the Department matters of common interest.

II.—*Investigations carried out for other Departments of State.*

The next subhead of National Research is far more important. It deals with investigations carried out for other Departments of State. It had been recognised from the beginning that if the Department were to initiate researches of its own on the advice of the Advisory Council without knowing the bearing they might have on the work or intentions of other Departments of State, confusion and worse than confusion might result. Accordingly, the Minister invited each Department of the Government to appoint one or more assessors to the Advisory Council. The assessors have the right to attend the meetings of the Council and receive the agenda papers and minutes of the Council. They also furnish the natural channel of informal communication between the Department of Research and the Departments they represent. This device has had the happiest results. The Council is informed from the first as to the attitude of the Departments concerned in any business which may arise, and difficulties are threshed out before proposals are formulated, and not after they have been adopted by the Department. Many Government Departments are engaged on research for their own purposes, and repeatedly the Council has deferred the consideration of proposed investigations which it learnt were engaging the attention of other Departments, even though the research might cover only part of the field, until the considered views of all parties concerned had been ascertained and unified. It has thus been possible on more than one occasion to remove overlapping already in existence, and to bring the workers under different Departments together into a co-ordinated plan of attack. The Council never knowingly enters a field of work already occupied, even in part, without previous agreement with the Departments concerned. The assessors on the Council have made this plan possible and easy. For more than a year past the Council has been similarly brought into touch with research work in Canada by the presence at its meetings of Professor McLennan, F.R.S., as assessor from the Canadian Advisory Council for Scientific and Industrial Research. But this is not all. The close understanding which has been reached with the administrative Departments of State has led them to request the Research Department to undertake for them a number of investigations which were less well suited for an administrative organ than for one like the Research Department, which is free from the embarrassments that administration of the law entails. Thus the Home Office invited the Department to investigate the question of mine-rescue apparatus. The first report of the committee established by the Advisory Council has proved on publication to be so valuable in directions hitherto unexpected, that the Commander-in-Chief in France asked that the committee might be placed in touch with General Headquarters. The Local Government Board invited the Department to undertake a series of researches into building materials in connection with the housing policy of the Government, and this led to similar requests from the Commissioners of Woods and Forests, as regards home-grown timber, from the War Office, and from the Board of Agriculture. So that from small beginnings a large body of researches into problems of building has been undertaken. These are but two examples out of many cases in which other Government Departments have welcomed the services which a Department of Research can render. The Advisory Council usually invites each Government Department concerned to nominate one of its technical officers to serve on any committee it may appoint to conduct research at the Government expense and for Government purposes, whether the proposal emanates from themselves or from some other Department. But it never appoints

an administrative officer to a research committee or to the research boards of which I am going to speak, for it is in their view essential to avoid any idea that the findings of a committee or board have been in the slightest measure the result of administrative policy. The findings of the committee must be taken on their merits, and the administrative Department or Departments concerned are free on their own responsibility to adopt or neglect them as they may find necessary or desirable. Nevertheless the Council is prepared when it is so desired to appoint administrative officers from the Departments concerned as assessors to a research committee or board, in order to keep the administration in touch with the direction in which the committee is moving—often a useful arrangement.

III.—*Research Boards.*

When a large group of researches has to be undertaken in the national interest and an elaborate organisation for research has to be set up, the Advisory Council has recommended the Minister to give the research committee a more independent status, and to place it in closer relation to himself. This is the third type of organ for national research, and is called a research board. The work done by boards is not only wide in scope and complex in organisation, but it is always work which for one or more reasons is not susceptible of organisation by an autonomous body like a research association. It is also work which must, because of this, be paid for altogether or almost altogether by the taxpayer. The first board of this kind to be established was the Fuel Research Board. Fuel and economy in its use affect the poorest worker in the land as intimately as the largest consumer. Fuel is the basis of all our industries and of our supremacy at sea. No association of manufacturers could be expected to attack so wide a range of problems in all its parts. The cheapest and fairest way of distributing the burden was to place it on the shoulders of the taxpayer. In a word, this was a typical piece of national research. The same arguments apply to the preservation of food as to the conservation of coal, and at a later date Lord Curzon established the Food Investigation Board to deal with this vastly important group of problems.

The Advisory Council had been considering the question of fuel at the earliest of its deliberations, and the report of Lord Haldane's Coal Conservation Committee made definite recommendations which led directly to the establishment of the Board. In the case of food the impetus came first from the Ministry of Food and the Board of Agriculture and Fisheries, both of which Departments were deeply concerned in the feeding of the people. Similarly, it was the Secretary of State for Home Affairs and the Medical Research Committee which, severally and within a single week, invited the Advisory Council to take up the question of industrial fatigue. This led to the establishment of the Industrial Fatigue Research Board, which, apart from the importance of its special field of work, is interesting because it was appointed jointly by the Research Department and the Medical Research Committee. One further example of a research board must suffice in illustration of this part of the Department's work. I refer to it not only because of its inherent importance, but because it shows the elasticity which the policy thought out by the Advisory Council permits. The Government decided to assume responsibility for the National Physical Laboratory as from March 31st last, on the invitation of the Royal Society, who had previously been responsible for its maintenance. The Laboratory had been administered since its inception by an executive committee appointed by the Society under the terms of a scheme approved by the Treasury, who made it an annual grant in aid. It was found on investigation that all the powers of scientific control exercised by the Royal Society through the executive committee could be continued if the executive committee were taken over as a research board by the Department. Accordingly this was done. The growth in the importance of the Laboratory during the war will be realised when you remember that the total income of the Laboratory in 1913–14 was £43,713 6*s.* 10*d.*, while the amount taken for the Laboratory in the estimates of the Research Department for the coming year, 1919–20, is £154,650.

The responsibility and initiative entrusted to a research board are very great. When the Minister has appointed a research board on the recommendation of the Advisory Council, the board is invited to prepare a scheme of work and a budget of expenditure. These are submitted to the Minister together with any remarks upon them the Advisory Council may wish to make. The Council does not amend the scheme or estimates of a board, for research

boards are responsible directly to the Minister and their chairmen have immediate access to him. The less important research committees are appointed by the Council itself, and are subject to its control both in their schemes of work and their proposed expenditure. The recommendations which go to the Minister are recommendations of the Council, not of the committees. But both research boards and committees, when once their proposals are approved, have full power to expend the appropriations made to them, subject only to the rules imposed upon all public expenditure by Parliament.

The Principle of Delegation.

The research boards and committees consist of men of science, men of business, and technical officers of the Government Departments concerned. They prepare schemes of work, select the researcher and determine the amount of his remuneration, but they do not as a rule conduct research themselves. They are executive bodies. The Advisory Council is not executive, but deals with general policy. Here again it will be seen that the procedure has been to delegate authority, even in the case of research carried out by the Government for national purposes to bodies of experts. It is a commonplace among administrators to fear the expert, and there is no doubt that, taken singly, he may be a very embarrassing and even dangerous being, but he is far less dangerous when he works with other experts of his own kind. If in addition the experts are confined to their own "expertise," as it has been called, they are no more dangerous than other able men, and as might have been expected, they do their own work better than others can do it for them. It was well said some years ago that the main problem which Government Departments would have to solve in the present century was how to use the expert. The Research Department is an experiment in this direction. The attempt to differentiate the work of the Department according to function, and give each class of work to the appropriate type of worker, has not only secured the strenuous assistance of the man of science and the man of business, each contributing from the fulness of his own knowledge, but it has greatly strengthened the position of the Civil servant whose business is administration. It has strengthened it because it has limited his responsibility to the matters which belong to his kingdom. The administrative head of the Department has no power to advise his Minister upon the scientific policy to be pursued, and it would be improper for him to do so, were he the most distinguished man of science in the country. Since he is only an administrator he is under no such temptation. If the scientific initiative emanates from the Minister himself or from another Department it stands referred to the Advisory Council. All other initiative derives from the Council itself. The duty of the administrative Civil servant is to advise the Council and the Minister of the bearing which any proposed line of action will have upon the work of other Government Departments and especially the Treasury, or upon the attitude of Parliament, or upon the finance of the Department. He has to deal with questions arising in the House and with the machinery by which the work of the Department is regulated. Finally, the Civil servant is responsible under the Accountant-General for the supervision of all expenditure and of all property held by the Imperial Trust, including patents, and funds held in trust for the Department. Here is plenty—which may properly engage the best energies of a well-trained staff of Civil servants. Lord Haldane's Committee on the machinery of government which has recently reported to the Minister of Reconstruction, sees in the experiment I have tried to describe the germ of what may ultimately become a great Department of Research and Information, influencing every administrative organ of the State, because it is the servant of them all. Be that as it may, the mere suggestion is an acknowledgment of the courageous faith with which the Government in 1915 set out upon this particular adventure, in reliance on the law that sound organisation is always based upon the proper differentiation of function.

To sum up. The activities of the Department are exercised in three main directions. First, it seeks to encourage the worker in pure research by looking for him in the places where he is most likely to be found, through the eyes of individual men and women who are themselves engaged in research and teaching others how to begin. When the man or woman has been found who needs assistance, they receive it in liberal measure, with no restrictions beyond the necessity of showing that they are continuing their work. Secondly, the Department is helping the firms in different industries to co-operate, with a view to raising the funds necessary for employing first-rate men of science in the solution of the problems with

which they are faced and in the scientific development of the industry in question. In this connection the Department is building up a clearing-house of information for the benefit of all concerned. Finally, the Department is offering its assistance, on the one hand, to other Government Departments who desire to have research undertaken on a scale and for purposes which they cannot themselves easily compass. On the other hand, it is organising research into problems of practical utility, which are of such wide importance that they cannot be handled by any one section of the nation. In both regards it proceeds by delegating the responsibility for the conduct of this work not to officials but to boards of experts, who are entrusted with the preparation of the scheme of work, the employment of the workers, and the control of its execution. The principle, as you will see, throughout is the same—the principle of delegation to those best fitted for the work in hand.

DISCUSSION.

THE CHAIRMAN (the Marquess of Crewe, K.G.), in opening the discussion, said that the author had given a most interesting account of the work connected with a remarkable Department. He used the word "remarkable" because one of the singular facts connected with the Department was that it should be a Government Department at all. So far as he knew, this was the only country in which a Government Department of Research existed. In the United States, which had gone far ahead in matters of scientific research, the National Council of Research was a purely voluntary body, entirely unsupported by public funds. It was placed in semi-official relations with the Government by the share it took as the scientific adviser of the Council of National Defence, but it was in no sense a public Department. As one of those who were fortunate enough to be associated with the origin of the Department, it had been a great pleasure to him to preside over the meeting and to hear the author's lucid account of its formation. It was only right to say that the original conception of such a Department came from the Board of Education, but it became quite clear that when it came into being it should not be a Department of that Board. Its scope was far too wide, and he was quite certain that the great industrial figures who now played so large a part in its operations would have regarded with a good deal of suspicion its too close attachment to the Board of Education. That being so, it was undoubtedly right to start it as an independent public Department under the Privy Council. Now that years had passed, and many new Departments had been created, it was a matter for congratulation that such a vastly important Department, although it made less stir in the public press than some others, had managed to keep on without the appointment of a separate Minister with a fresh title and salary attached.

SIR JOSEPH J. THOMSON, O.M. (President of the Royal Society), desired to congratulate the author on the very lucid account he had given of the work of a Department whose success was so largely due to his efforts. The author had divided his subject into three parts. To the second and third, dealing with the application of science to industry and the various steps that had been taken to promote the extension and the effectiveness of such application, his own feelings were entirely those of a friend; but to the first, that steps should be taken to promote the interests of pure science, his feelings were even warmer—they were those of a lover. He desired to confine his remarks to that part of the subject because immediate action was necessary in connection with it, as the situation was now most acute. The author had quoted the words of Humboldt to the effect that Government interference in scientific subjects was entirely bad. If Humboldt could be taken to mean that he thought that in the higher departments of scientific activity direct Government organisation would be useless, he agreed with him, and he desired to illustrate that point by taking the analogy of literature. He believed the Government could set up a department which would improve very effectively the production of dictionaries and encyclopædias, perhaps even sermons and leading articles, but he did not think any man would maintain that such a department would do much for poetry. He imagined it would be difficult to get anybody to read poetical effusions that emanated under Government control. Great ideas in science were as wayward as the fancies of a poet, and they could not be controlled and organised by any Government department. Great new advances in science had for the most part been made in universities. Of course we had the work of such men as Darwin and Joule; but, speaking generally, it was the universities that had been the birthplace of great ideas in science, and it was to the universities that it was necessary to look for new ideas. But though the Government should not control scientific research they could encourage it; and the universities of this country were at the present moment in a desperate state. They existed to a very large extent upon endowments, the money value of which had been halved, while, so far as the working expenses were concerned, the cost of apparatus for laboratories had gone up two or three times. The universities could not carry on under present conditions. Nobody wanted to increase the fees that the students had to pay, because it was the universal wish that education in this country should be as cheap as possible; so that the universities could not look to an increase in fees to meet the necessities of the time. Yet there were indications that the universities would

be flooded with students in larger numbers than before the war. In his own college 300 undergraduates had come back in the course of three weeks. Last term there were only 30 undergraduates; at the present time there were over 300 in residence, and fresh applications were coming in every day. He was sure the universities would be more populous after the war than ever before, and their expenses on that account would be greater. The universities were in urgent need of assistance from some source or other, and if it was not given he was quite sure it would be a grievous blow to research in this country, and indirectly to the work of which the Advisory Council had control.

Sir Robert A. Hadfield, Bt., F.R.S., said he strongly dissented from the statement made by the author that our enemy was more zealous in the pursuit of science than any other nation. Personally he thought the Germans had been very apt in copying what other nations had done, and by their system of organisation they had been able to apply that knowledge successfully. Some of their contributions to scientific knowledge, however, were not such as this country wished to copy. He thought the people of this country had believed that the Germans were clever because of their extreme patience and labour. He found it was possible to go too far in that direction. Personally, he thought they were rather old-fashioned and, like their *Kultur*, it was not desirable for us to copy them. He had been delighted to hear the remarks made by the President of the Royal Society. He did not see how true researchers could possibly be organised. The true scientist or the true inventor must be beyond all control, and must be left alone; then, if he was trained properly in the first instance, he would very quickly make his value felt to the nation. He could not imagine Lord Kelvin, for instance, ever having been a researcher except in that sense. He was unique and alone; and the more such very able men were left to follow their own lines of work the better it would be. He was sorry that fuller reference had not been made to the National Physical Laboratory, which was organised many years ago. That laboratory had done work of the greatest importance without organisation of the kind referred to. The author in one part of his paper had mentioned university work, and in that connection he desired to bring to the notice of the audience the work of Sheffield University, which maintained a very intimate touch between the practical and the scientific sides. Sheffield men went for help to their university, whether in connection with pure science or applied science. He could not imagine any better system of working together than existed in Sheffield University, and it was an example which might well be followed by other cities. During the war not only had great assistance been given to the various producers of war material from the scientific point of view, but the university had done excellent practical work. Reference had been made also to the question of Government interference during the war. Whilst everyone admitted that during the war Government interference was necessary, he thought the general feeling throughout the country now was that the sooner it was got rid of the better. He hoped the idea of the formation of research associations would not interfere in any way with the dissemination of knowledge. Speaking from the scientific point of view, he most strongly dissented from the wrapping up of information. The Germans had not done any better than this country, whatever secret methods they had of carrying out their work; and he was rather afraid that if the research associations followed the lines which had been indicated harm would be done. In his opinion the best plan to adopt was for an investigator or researcher to describe his work to a scientific or technical society. When he invented manganese steel, now widely used in every country, he presented a paper on the subject to the Institution of Civil Engineers, with the result that the matter was thoroughly discussed, not only in this country but in many others. That led to knowledge being quickly spread, and much work in similar directions in regard to various alloys was carried out. If, on the other hand, he had taken the results of his work to a research association on the lines indicated in the paper, it might have been kept secret, and he did not think that was what was required. The more information was disseminated, the better it was for the nation at large. Even supposing some other nation did benefit a little from it, he hoped this country would always possess the proud privilege of leading the way, as it had done in the past.

Sir Herbert Jackson, K.B.E., F.R.S., said that the actions of the Department had to some extent been criticised, because they might have some adverse effect on individual enterprise. Personally he did not think there was any danger of that sort of thing occurring. Looking back on the actual research work done in some of the industries, he thought it was not sufficient, in this country at any rate, to leave everything to individual enterprise in order to secure national prosperity and prestige. Everybody agreed that it was wrong to attempt to hamper the worker in pure research, and he did not believe research associations would have the effect of doing anything of the kind. In his opinion the research associations would find it necessary continually to ask the aid of the pure researcher in the universities and leave him entirely unhampered, and that aid would be asked for only if the research associations found they were in a position to help financially in the conduct of the researches. There were many important fundamental researches which must be carried out before applied research could be of any value. It was no good only knowing how to do a thing; it was necessary to know the why as well as the how. If research associations could shape

themselves so that they kept in mind the whole time the necessity of fundamental work, he thought they would react admirably on the work of the universities and encourage the best pure science that could be put forth in the country.

LORD GAINFORD said the Department had worked under great difficulties owing to the war. Young men to whom the country looked to carry out researches had been enlisted in the Army, and the nation had been deprived of their efforts during the past four and a half years. At the same time the work of the Department had gone on, but information as to its activities had to a very large extent been concealed from the country. He thought, however, a stage had now been reached when the country should realise that the Department was a real live Government Department, ready to help all those who were going into research work with a view to assisting in the carrying out of the enormous projects to which efforts would be turned in the immediate future. The country possessed in Sir William McCormick and Sir Frank Heath men who could be fully trusted, and there was a large number of capitalists who were quite willing to place money in industrial research that required encouragement. He thought chemists and scientific men had hitherto been paid much too little, and it was only by the press helping in the great work in hand that it would be possible to succeed in drawing the attention of the capitalist and of the industrial concerns of the country to the matter. Not many industries, unfortunately, were led by scientists of the stamp of Sir Robert Hadfield, who was not only a scientist but took a practical interest in the work of his firm. It was essential to have scientific men associated with capitalists and those who were prepared to develop the industries of the country. The Department that had been set up was willing and ready to help all organisations, and he trusted much use would be made of it in the future.

SIR ROBERT L. MORANT, K.C.B., thought it was extremely important at the present time that business men, on the one hand, and scientific men on the other, should study the extremely difficult modern problem of the relation of the State to scientific work. It was easy to say that science had been starved, and that more money ought to be spent on it, and to ask what was to happen to the universities in view of money being worth only half its pre-war value. It all came back to the cry for more State aid; but it was perfectly plain that Exchequer money was not going to be ladled out unless Parliament knew what was being done with the money, and had what it regarded as adequate control. Parliament in the main was a lay body; the layman was constitutionally jealous of the expert, and he desired to keep an eye upon what happened to the money that he voted. In the course of the evolution of the Department, very careful consideration had been given to the problem how to secure a larger amount of Exchequer money to aid the prosecution of research, pure and applied, without that aid involving such kinds of control as would stifle the very things it was intended to aid. He hoped as a lay administrator that scientific and industrial men would address their minds to that precise issue. It was easy to say that it was necessary to get rid of State control, but it was useless if at the same time it was urged that more State money must be available. The problem which had to be studied in the much abused Government Departments was how to accommodate those two principles, and it could only be done by all concerned coming together, finding out what were the requirements and accommodating them. It was also necessary to find out how Parliamentary control could be so worked that it would not stifle the very thing which the Exchequer grant was intended to aid and develop. The experiment described in the paper was in the real sense an experiment. It was liable to alteration year by year. It partly grew out of an earlier and more dangerous experiment of a Government Department in relation to the universities, and it was a very delicate process, hailed with objurgation by many who cared most for the universities. The same early stage was now being gone through in regard to research as distinct from the universities in the ordinary sense, and it would only prove to be a success if the scientific men on the one hand and the industrial men on the other would address their minds to the exact point, namely, how to secure adequate Exchequer control without its being spoiled by a wrong form of intervention. It was necessary to have a carefully thought-out accommodation of two apparently opposed principles. The growth of the Department would be watched with keen interest. It possessed an adaptability which ordinary Government Departments did not possess, but there was no doubt at all that the urgency of the problem could not be exaggerated.

SIR WILLIAM S. MCCORMICK (Chairman of the Advisory Council for Scientific and Industrial Research) said it was most gratifying that the paper of his colleague had met with such a hearty reception from the meeting. He had been specially interested in the point made by Sir Joseph Thomson with regard to the universities. Personally he had great hopes that the Government were beginning at last to realise the extreme urgency of helping the universities in their present depleted condition. With reference to the remark made by Sir Robert Morant, as a sort of go-between between science and governmental control, he had had rather a bad time of it for the past three and a half years, but his experience had conduced to hopefulness. The elasticity of the experiment was its great hope, and he was sure that with good temper and sympathy on both sides a solution would be arrived at. As he had received a good deal of criticism from men of science, he desired to make a few remarks in return. On the one hand, men of science were often apt to think of physical science as the only science

in existence, forgetting that there was a science of human nature; a science of government, especially of the present democratic government; a science of administration; a science of business; and he had many times felt that scientific men were apt to belittle every science except their own. A great many men who were experts in science apparently did not know how their country was governed. They found difficulties in procedure which ought to be easily intelligible to any man who was a citizen of a democratic nation. It was necessary for them to realise that they lived in a community which, if public money was expended, had a right to ask how it was expended and what they obtained for it. On the other hand, there was in certain Departments in this country with which he had occasionally come in contact a great deal too much red tape. There was red tape and red tape. There was a certain class of red tape which, if used properly, relieved people from difficulties and misunderstandings; and if any scientific man had a grievance against the Department in that respect he hoped he would see the author or himself, and that during an interview of half an hour it would be possible to find a satisfactory solution.

On the motion of the CHAIRMAN, a hearty vote of thanks was accorded to the author for his interesting paper, which SIR FRANK HEATH briefly acknowledged, and the meeting terminated.

MR. HERBERT WRIGHT writes:—The shortage in the numbers of trained research workers referred to by the author is at the root of the difficulty. There was a shortage in pre-war days, and despite the reported large influx of demobilised men to our universities and colleges, I am of the opinion that the shortage will continue for many years if greater attractions are not offered to students. I have found during the last few weeks that many demobilised officers who previously had passed through medical, chemical, and engineering courses, no longer desire to follow up their original studies but prefer appointments which will allow them to lead an open-air life. In the laboratories of firms of repute the number of trained research workers is very small, and the greater part of the work is unfortunately left to men and women who have been trained solely in the works' laboratories. This means that there is a strict limitation of the quality and quantity of research work which could be done: the only remedy seems to be to see that all research workers are brought into contact as frequently as possible with the best brains in the country. Two reasons could be advanced for the shortage. In the first case, many employers do not assess the services of research workers at a high figure, and accordingly it is the rule to offer only very low salaries to graduates. Secondly, many manufacturers prefer to use their own men, trained in their own works, rather than accept the services of well-trained investigators from universities or colleges of university standing. In my opinion the fact that many important industrial concerns prefer to train their own technologists in their own works is a severe indictment on university facilities provided in the past. Our educational authorities should offer greater facilities to young men and women who are prepared to devote their lives to science and technology. If the status of science and technology is not raised I believe that industry will suffer for all time, and the requisite number of research workers will not be forthcoming. I was particularly interested in the remarks made by Sir Robert Hadfield on the work being done in pure and in applied science at Sheffield University. I regret that the City of London, the heart of our Empire, is not able to claim a university solely devoted to science and technology. The time has arrived when London should at least follow the excellent example afforded by the provinces, and create at least one university which would be devoted entirely to pure and applied science. There was another point referred to by Sir Frank Heath on which I should like to comment. He observed that the subscriptions paid by the members who joined an association could be regarded as direct expenditure against revenue, and that these amounts were therefore exempt from "Income Tax and Excess Profits Duty." This is a great concession on the part of the Board of Inland Revenue, but no mention was made of the fact that the Chancellor of the Exchequer has already announced in the House of Commons that with the conclusion of war the Excess Profits Duty will come to an end. In view of the prospective removal of the Excess Profits Duty I suggest that the business houses who contemplate associating themselves with industrial research should have an assurance that any subscriptions they may make will be free from "present or future taxes." It is only fair that such an arrangement should be entered into in order that the concession already granted may be taken advantage of when the Excess Profits Duty Act is repealed.

MR. A. E. PARNACOTT writes:—I wish heartily to support Sir Robert Hadfield's clearly expressed views at the discussion on the above paper. I think he is the one industrialist who took part in this discussion. Amongst industrialists there is a general conviction that the proper place for pure scientific research is the university; general research and invention would seem to have been somewhat confused in the discussion. Research and invention are, in my opinion, the very last things that can be organised and co-ordinated by the bureaucracy. Individual effort has in the past in this country been so successful and productive in scientific research that any form of control of the worker or favouritism of those under control can only be a national calamity. Our civilisation is the direct consequence of the work of the originative engineer and chemist. We have already some institutions which know clearly what they are doing and what there is to do, *i.e.* the science

departments of the universities, and the National Physical Laboratory, which should have all the money they require without stint in order that this nation may continue to lead in this class of work. Previous to the war, it seems to me, those of the community chiefly to blame for the ascendancy of our foreign competitors were the business men; but I can offer an explanation why they failed in those industries directly dependent on scientific research and invention. It is that originative work is not considered worth while; the huge cost and the very short period of adequate Patent Office protection have two effects; it is too costly for the average man to protect a novelty by a number of patents, as it is now desirable to do, and it generally takes up to ten years to get the value of a patent appreciated or ready for production on the market in quantities promising to be remunerative, by which time there are only a few more years to run in which to make up for the ten long lean years of worry, energy and the financial risk involved. Originative work must be made worth while. The Government scheme for the organisation, I venture to predict, will not be a lasting success, whereas if the cost of patents had been reduced and the term of the patents increased to fifty years or more there would be a direct encouragement in this country of the creative, non-parasitic workers, whose chief reward at the present time is the conviction that they are the makers of civilisation.

ENGINEERING NOTES.

Flexure of Beams.—When a beam, the weight of which can be neglected, has one end built into a wall and the other end loaded, the flexure of the beam is accompanied by a twist of successive sections with respect to each other, unless these sections are symmetrical. According to *Nature*, the relation between the flexure and torsion has been worked out for beams of certain simple sections by Mr. A. W. Young, Miss E. M. Elderton, and Professor K. Pearson, in a Draper's Company research memoir recently published. Some of the conclusions have been verified experimentally, and the authors hope that the research will serve as a first step towards the understanding of the relation between flexure and torsion in propeller blades.

The Heating of Trains and the Problem of Coal Saving.—This is the title of a paper read at the Institution of Locomotive Engineers by Mr. J. Carlier. At the present moment such a paper is particularly opportune, as the necessity of saving coal on railways and industrial plants as well as domestically was never at any time more vital. The object of the paper referred to is to comment upon the advantages of the Bouhon system of feed-water heating, and some interesting technical considerations relative to the subject generally are included. Mr. Bouhon has been at considerable pains in estimating the consumption of steam in connection with train-heating, and the conclusion he has arrived at is that, with trains of medium length, 60 lb. per minute is reached. For a train running eight hours per day the steam used would be about 28,800 lb., and the coal required to produce that amount of steam would be $\frac{28800}{8}$ lb. = 3,600 lb. per day. On this basis the amount of coal consumed in the course of six months for heating the train would be 280 tons, but the author admits that in order to provide a sound basis of discussion it would be wise to reduce these figures by 50 per cent. Even then it would seem that a locomotive consumes annually something like 145 tons of coal, and even more for the heating of trains. It is contended, therefore, that the heating of trains by means of recuperating the waste products of combustion from the boilers of locomotives represents a very important economy.

Waterway from Ukrainia to the Baltic.—After the Lubeck Chamber of Commerce some months ago revived the old Russian plan of a waterway from Cherson to Riga, the Ukrainian Government in June took up the question of the proposed waterway from Cherson to Danzig, or Königsberg, and decided to have plans prepared for the development of the Dneiper, and to examine the possibilities for a connection to the Baltic. A commission was appointed of two engineers and an interpreter, which during July visited a number of Baltic ports, and conferred with representatives of the Government, trade, industry, and navigation in Danzig and Königsberg, where detailed proposals for the development of the waterway were put forward. As a result of these conferences the Ukrainian Government has decided to proceed with the plans of all three routes, *i.e.* those to Riga, Königsberg and Danzig respectively. The *Hamburgischer Correspondent* hopes that the German Government authorities will devote special attention to these canal schemes, which it considers no less important for the future economic advantage of Central Europe than the Danube-Main doorway, for the preliminary operations of which 1,000,000 Marks were allotted last year. The *Kölnische Zeitung* points out that a ship-canal to Danzig would afford the shortest connection between the Central and West German canal system on the one hand, and the inland waterways of Ukrainia on the other.

Weight of Ferro-concrete Vessels.—It is so obvious that ferro-concrete vessels are heavier than steel ones that there is no need to explain why. The important point is to make a comparison between vessels of the two classes, and of same dead-weight carrying capacity. This information is derived from a paper read by Mr. T. J. Querette, of the North-East Coast Institution of Engineers, Newcastle-on-Tyne. The designs of vessels of 1,000 tons deadweight and upward prepared by the author's firm comprise one-deck, single-screw, cargo vessels of 1,000, 2,000, 4,000 and 6,000 tons weight, and the comparison is limited to those.

The excess displacement of ferro-concrete vessels over steel vessels of same deadweight carrying capacity is as follows:—Deadweight all told, in tons, 1,000, excess 39 per cent.; 2,000, 25·8 per cent.; 4,000, 16·5 per cent.; 6,000, 11·8 per cent.

Hardening of Lead.—It is known that an addition of a small quantity of sodium or magnesium to lead hardens the metal considerably. If tin be added to either of these alloys its brittleness is somewhat diminished, and its resistance to chemical action accordingly increased. According to *Metall und Erz*, an alloy of soft lead and magnesium, which, in moist air, is slightly attacked on the surface, is proof against such action when tin is added. The proportion of sodium or magnesium added should not be greater than 4 per cent.

Japanese Steel.—The estimated output of the Japanese State Steel Works at Yawata, says the *Indian and Eastern Engineer*, is put at 400,000 tons, of which 380,000 tons are guaranteed. According to a decision lately reached with regard to the allotment of this output, 14,000 tons will be assigned to the Navy, 62,000 tons to the Army, 70,000 tons to the Imperial Railway Bureau, 55,000 tons to other Government services, and 174,000 tons will be allotted for general purchase.

Pneumatic Riveting Tools.—News of these tools comes from both Clyde and Tyne areas. It has been one of the most marked features of the work Clyde shipyards during the last two or three months, and by the end of the year the extended use of these tools will be reflected in the greater output of vessels on the river.

Irish Coal Mines.—It is announced, in the *Electrical Review*, that the Irish Coal and Lignite Co., Limited, is about to commence operations in co. Tyrone, at an early date. Systematic boring will be made at Coalisland, and in the country between that town and Lough Neagh, under which both coal and lignite exist, it is believed. The Tyrone coal burns with an intense heat, and largely is of good quality, some of the coal seams being equal to Wigan coal. As to the lignite, it is estimated that the machines provided will be capable of turning out from 10,000 to 15,000 tons of briquettes per week. The deposits of lignite round Lough Neagh are very extensive, and other deposits exist in co. Antrim, co. Derry, etc.

The Rolling of Metals.—At a meeting of the Birmingham Metallurgical Society, a paper was read by Mr. F. Johnson and Mr. W. Robertson on this subject. The authors described the various processes adopted in rolling brass and copper, and made the interesting statement that whereas before the war German makers of rolling machinery were pre-eminent in the high-grade finish of their mills, and so obtained English custom, during the past three years English makers had made very rapid strides, and to-day could produce rolling plant in every way superior to that of Germany. A still greater improvement has been made with respect to rolls. Before the war we imported huge quantities of thin-gauge copper because Germany used a high-grade steel roll against our old-fashioned chill iron, upon which fine work could not be produced. To-day a special steel roll is being turned out which is superior to the German steel roll, and will enable the finest gauge rolling to be done in this country.

OBITUARY.

Ernest Octavius Walker, C.I.E.—The death took place on the 17th inst. of Mr. Ernest Octavius Walker, who had been a Member of the Royal Society of Arts since 1894.

Born at Teignmouth in 1850, he was educated at Thorn Park School, Teignmouth, Regent's Park College, and Hartley Institute, Southampton. He entered the Indian Telegraph Department in 1871. In 1889-90 he was in charge of telegraphs in the Lushai Expedition, and for his services he was mentioned in despatches and created C.I.E. He retired from the Department in 1892, after which he was Superintendent of Telegraphs in Ceylon from 1895-98. In 1894 he read a paper before the Indian Section on "Telegraphic Communication between England and India." He frequently attended the Society's meetings, occasionally taking part in the discussions; and he was present at a Cantor Lecture within a week of his death.

GENERAL NOTES.

Complete Substitute Lubricant.—The *Weser Zeitung* reports the founding of a new undertaking, the Potash Mineral Fat Co., with headquarters in Essen. Its purpose is the production of a complete substitute heavy lubricant which can be used as a traction-car and cart lubricant. The manufacture of these lubricants has been attended with the greatest difficulty during the war, as the necessary raw materials had to be procured from abroad. It is reported that the new discovery will make Germany independent of foreign imports. The raw material for this new fat will by preference be obtained from potash. The other requisite products will also be obtained exclusively from home industries, partly from the by-products of pit-coal.

American Army Refrigerating Plant.—One of the features of the intermediate depot for the American army in France is the big refrigerating and ice-making plant which has been in operation since May 2nd. It serves as a cold-storage house for meat and other perishable products, and was originally designed to have a capacity of 5,000 tons of frozen meat at 12° F., in addition to the production of 500 tons of ice daily. According to

Power, the first plans had been altered to some extent as regards the temperature in the cold-storage rooms. To obviate the necessity of icing the railway cars in which the meat is transported from the refrigerating plant to the Front, a lower temperature than that originally contemplated has been adopted. Refrigeration is by direct expansion of the ammonia circulating in coils hung from the ceiling of the building, which is divided into five rooms, each with a capacity of about 1,000 tons of meat. Means are also provided for storing vegetables and other products at a higher temperature than is maintained in the meat-storage rooms. As an indication of the size of this plant it may be noted that for the refrigerating coils alone thirty miles of 2-inch pipe were required.

TRAINING CANAL WORKERS.—Sir Maurice Fitzmaurice, Chairman of the Canal Control Committee, in giving evidence before the Select Committee on Transport within the United Kingdom, said that some of the canal companies objected to use men who had not been accustomed to canal work, and there did not seem any great anxiety on the part of the companies to give them a chance of learning the business. A training school was therefore started at Devizes, on the Kennet and Avon Canal, which was very little used. Boats and horses were bought, and the men trained in loading and unloading barges, in taking them through locks, and in horse management. The men went from the Transport Workers' Battalion in batches of thirty, and the course of training lasted about three weeks. After a time the canal companies realised that men could be trained in this way, and some of them began to train men for themselves. When the school had been in existence for ten months it was unnecessary to continue it longer. The number trained at Devizes was 209. The horses and barges were subsequently sold. The net cost of the school was £862, or about £4 per man trained.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

FEBRUARY 26.—W. L. HICHENS (Chairman, Messrs. Cammell Laird & Co.), "The Wage Problem in Industry." W. A. APPLETON, C.B.E., Secretary, General Federation of Trade Unions, will preside.

MARCH 5.—B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present." PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, will preside.

MARCH 12.—WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

MARCH 19.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

MARCH 26.—ARNOLD HARTLEY GIBSON, D.Sc., M.I.Mech.E., Professor of Engineering, University College, Dundee.

APRIL 2.—W. NORMAN BOASE, "The Cultivation and Preparation of Flax, and the Linen Industry." LORD COLWYN will preside.

APRIL 9.—LEONARD ERSKINE HILL, M.B., F.R.S., "Housing and Infant Mortality."

APRIL 30.—SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

MARCH 6.—W. R. GOURLAY, M.A., C.I.E., I.C.S., "The Need for a History of Bengal."

MARCH 13.—D. T. CHADWICK, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission."

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

FEBRUARY 25.—EDWARD J. DUVEEN, Fellow of the Royal Statistical Society, "Key Industries and Imperial Resources." W. A. S. HEWINS, M.A., late Under-Secretary of State for the Colonies, will preside.

MARCH 4.—PROFESSOR JOHN CUNNINGHAM MCLENNAN, O.B.E., Ph.D., F.R.S., Scientific Adviser to the Admiralty, "Science and Industry in Canada." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 27.—SIR EDWARD DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced :—

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Design in Japanese Art."

J. N. Spencer Williams, "The Hawaiian Islands and their Industries."

John Somerville Highfield, M.Inst.C.E., M.I.E.E., "The Supply of Electricity."

Sandford J. Kilby, "Indian Salt Manufacture."

Cantor Lectures.

Monday afternoons, at 4.30 p.m.

J. A. Fleming, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

Syllabus.

Lecture III.—February 24.—The detection of electromagnetic waves — Magnetic, electrolytic, thermionic, and crystal detectors — Receiving arrangements—The development of the thermionic detector—The Fleming valve—The three-electrode valve in radiotelegraphy and radiotelephony.

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." Three Lectures.

March 10, 17, 24.

Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

Monday, February 24 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Dr. J. A. Fleming, "Scientific Problems in Electric Wave Telegraphy." (Lecture III.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m.

Geographical Society, Burlington - gardens, W., 8 p.m. Lieut.-Colonel H. S. L. Winterbotham, "Geography with the British Armies in France."

Tuesday, February 25 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Mr. E. J. Duveen, "Key Industries and Imperial Resources."

Illuminating Engineering Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Mr. A. Cunnington, "Some Notes on Railway Lighting and its Maintenance."

Royal Institution, Albemarle-street, W., 3 p.m Captain G. P. Thomson, "The Dynamics of Flying." (Lecture II.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Mr. F. J. Mallett, "The Flow of Water in Pipes and Pressure Tunnels." 2. Mr. A. A. Barnes, "Discharge of Large Cast-Iron Pipe-Lines in Relation to their Age."

Anthropological Institute, 50, Great Russell-street, W.C., 5 p.m. Mr. W. M. M'Govern, "Formosan Anthropology."

Colonial Institute, Central Hall, Westminster, S.W., 4 p.m.

Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. Mr. W. B. Wright, "An Analysis of the Palæozoic Floor of North-East Ireland, with Predictions as to concealed Coalfields."

Industrial Reconstruction Council, 2, Tudor-street, E.C., 6 p.m. Miss Newcomb, "Welfare Work."

British Women's Patriotic League, South Lodge, Rutland-gate, S.W., 3 p.m. Sir J. B. Matthews, "Strait Settlements and Federated Malay States."

Wednesday, February 26...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. W. L. Hichens, "The Wage Problem in Industry."

Aeronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Captain F. S. Barnwell, "Some Points on Aeroplane Design."

Geological Society, Burlington House, W., 5.30 p.m. Lieutenant E. H. Pascoe, "The Early History of the Indus, Brahmaputra, and Ganges."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor E. W. Hope, "The Rôle of the Ports in the Protection of the Health of the Nation."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Professor Sir Henry Newbolt, "Poetry and Time."

Thursday, February 27 ... Pottery and Glass Trades' Benevolent Institution, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. "Inaugural Meeting to consider a Scheme to further Technical Training."

Royal Society, Burlington House, W., 4.30 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Dr. P. B. Ballard, "The Claim of the Individual Child."

Britain and India, 7, Southampton-street, Holborn, W.C., 3 p.m. Mr. A. Dickinson, "The Industrial Development of India."

Royal Institution, Albemarle-street, W., 3 p.m. Professor H. M. Lefroy, "How Silk is Grown and Made." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. J. D. Johnston, "From Alps to Appenines."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Dr. S. F. Barclay and Dr. S. P. Smith, "The Determination of the Efficiency of the Turbo-alternator."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. E. Willis, "Industrial Safety First."

Friday, February 28 ... Royal Institution, Albemarle-street, W., 5.30 p.m. Sir Oliver Lodge, "Ether and Matter."

Saturday, March 1...Royal Institution, Albemarle-street, W., 3 p.m. Hon. J. W. Fortescue, "The Empire's Share in England's Wars — Eastern Empire." (Lecture II.)

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—February 21, 1919.

No. 3458. FEBRUARY 28, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers over three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2)

Journal of the Royal Society of Arts.

No. 3,458. VOL. LXVII.

FRIDAY, FEBRUARY 28, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

TUESDAY, MARCH 4th, at 4.30 p.m. (Colonial Section.) PROFESSOR JOHN C. MCLENNAN, O.B.E., Ph.D., F.R.S., Scientific Adviser to the Admiralty, "Science and Industry in Canada." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

WEDNESDAY, MARCH 5th, at 4.30 p.m. (Ordinary Meeting.) B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present." PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, will preside.

THURSDAY, MARCH 6th, at 4.30 p.m. (Indian Section.) W. R. GOURLAY, M.A., C.I.E., I.C.S., "The Need for a History of Bengal." The Right Hon. LORD CARMICHAEL, G.C.S.I., G.C.I.E., K.C.M.G., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On Monday afternoon, February 24th, PROFESSOR J. A. FLEMING, D.Sc., F.R.S., delivered the third and final lecture of his course on "Scientific Problems of Electric Wave Telegraphy."

On the motion of the Chairman, Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, a vote of thanks was accorded to Professor Fleming for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

COLONIAL SECTION.

Tuesday afternoon, February 25th; Mr. W. A. S. HEWINS, late Under-Secretary of State for the Colonies, in the chair. A paper on "Key Industries and Imperial Resources" was read by Mr. EDWARD J. DUVEEN, Fellow of the Royal Statistical Society.

The paper and discussion will be published in a subsequent number of the *Journal*.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Physical Chemistry and its Bearing on the Chemical and Allied Industries," by JAMES C. PHILIP, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, have been reprinted from the *Journal*, and the pamphlet (price 1*s*. 6*d*.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2)

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 26th, 1919; SIR GEORGE RANKEN ASKWITH, K.C.B., K.C., D.C.L., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

McLean, William Hannah, M.Inst.C.E., Alexandria, Egypt.
Merriam, C. P., London.
Roberts, Walter, Stockport.
Scrivener, Frederic Adam, London.
Singh, His Highness Raja Sir Bhuri, K.C.S.I., K.C.I.E., Punjab, India.
Tetsall, Ernest Peter, Ipswich.

The following candidates were balloted for and duly elected Fellows of the Society:—

Alcock, Walter James, London.
Almond, Rev. George, Nebraska, U.S.A.

Armstrong, Charles Hendrie Barrington, M.D., J.P., Kingston, Jamaica.
Braithwaite, Albert, Cobham, Surrey.
Clark, Joseph, Winnipeg, Canada.
Driver, James Hutchinson, J.P., Woking, Surrey.
Ironside, E. Allan, London.
Marple, George Smith, Sheffield.
Marsh, J. Parker, Sheffield.
Martin, John W., Belfast.
Martin, Major Robert, V.D., J.P., West Hartlepool.
Perks, William, Worthing.
Raffé, Walter George, A.R.C.A., London.
Solomon, G., Karachi, India.

The paper read was—

THE WAGE PROBLEM IN INDUSTRY.

By W. L. Hichens

(Chairman of Cammell Laird & Co., Ltd.).

The greatest problem that has to be faced in this country to-day, indeed that calls for settlement throughout the whole civilised world, is the relation between labour and capital. An antithesis which is in many respects false has been set up between these two great factors in production, and the community of interest which is the real foundation of both has been overlaid by less essential differences. For without labour capital is a drug in the market, and without capital labour is as a watch without its mainspring. Modern industry is impossible without a plentiful supply of capital, and the greater the industrial developments in any country become the more urgent are the demands for increased capital. If the world-old cry for *novæ tabulæ* were realised to-day, if by a revolutionary stroke of the pen all capital were confiscated and all capitalists were blotted out, the next act of the destroyers would necessarily be to breed up a new race of capitalists, to offer such inducements as might be necessary to persuade people to save a portion of their income and devote it to schemes of future development instead of spending it on the desires of the moment. For there is no other source from which capital can be derived except savings, and no one will save unless he has a sufficient motive. True, the sole motive for saving need not be the *auri sacra fames* which economists are wont to extol; but it is equally true that unless some financial compensation is offered for the sacrifice of immediate enjoyment which is involved, the majority of people will not save—the necessary capital will not be forthcoming.

Hence antagonism between capital and labour is not of primary, but of secondary importance, the fundamental fact being that each is essential to the other. It is the community of interest between capital and labour which must always be the basis of industry, and the success of any schemes which are based on the suppression of the one or the oppression of the other will involve the whole industrial edifice in ruin because the foundations will have been destroyed.

But human nature is such that we tend to pursue the shadow instead of the substance. We are so busy quarrelling as to how we shall cook our hare that we fail to catch it; we are so pre-occupied with the distribution of wealth as between capital and labour that we tend to forget the laws governing its production; we divide up our cake before it is made, and are in danger of waking up one day to the unpleasant reality that we have elaborately arranged for the distribution of something which does not exist.

I have begun my paper purposely with what may appear to many to be a digression, because in considering the question of the division of the proceeds of industry as between labour and capital, which is the essence of the wage problem in industry, it is necessary always to bear in mind that this problem cannot be considered in isolation from that of production—that the one inevitably conditions the other, and must be determined in relation to it. Most people will, I think, agree that we are inclined to ignore this relationship in practice. For, on the one hand, if an increase in wages is opposed by employers they are apt to ignore its effect upon the productive capacity of the workers. They do not fairly balance the effects produced by discontent, by a lowered vitality, by a loss in efficiency, against the more obvious economies of a low wage; they do not study with the care that it deserves the problem of industrial fatigue; indeed, they are sometimes disinclined even to allow the problem to be studied for them because they regard it as a new-fangled idea; they do not always devote the same care or thought to the efficiency of the human machine as to the inanimate machinery of their workshops; they do not always realise that we are all largely conditioned by our environment, and that it is unreasonable to expect the high ideals, the generous instincts, the well-balanced mind, which are prime factors in developing the best workmanship, to flourish in squalid surround-

ings amidst the deadly monotony of grinding poverty.

The workers, on the other hand, make their demand for increased wages with little or no regard to its probable effect in restricting production. They think vaguely that all increases can come out of profits, and do not pause to consider what will happen if the profits are insufficient for the purpose, as they nearly always are, and if the increase must be met, as it nearly always is in the long run, by a rise in prices. A general increase in wages followed by a general increase in prices leaves them no better off than they were before, but rather worse off; for not only will the cost of living increase, but, what is even more serious for them, consumption will be reduced and unemployment will supervene. To be really effective an increase in wages must be conditioned in one or all of three ways:—

1. It must be accompanied by a reduction in profits, so that a part of the wealth previously going into the pockets of the capitalist may accrue to the worker. But this is only permanently possible if the rate of interest left to the capitalist is sufficient to attract fresh capital—*i.e.* to encourage saving—for no industry can exist without a continuous inflow of fresh capital.

2. The increase must be particular, not general; it must not extend to all trades and classes of workers. An increase in wages really means an increase in relation to somebody else; otherwise it loses its value, for if the wages and salaries and profits of everybody were all increased proportionately at the same moment nobody would be one whit better off than they were before. Money is, of course, merely a token, and to multiply the number of tokens that each individual possesses adds nothing to the realities for which they stand. To increase the points for which you play at bridge involves no increase in your capacity to pay your losses—rather the reverse.

3. Increased wages must be accompanied by increased production. This is by far the most important factor in ensuring a real as opposed to a nominal increase in wages. In other words, increased wages must be conditioned by increased efficiency. It may be that the added productivity is brought about by improved mechanical devices—and there is an ever expanding horizon before us as we advance along the roads of science—or it may be that increased well-being will bring greater efficiency in its train. In this case there will be some reality behind the token increases, and the result will be a permanent gain to the whole community instead of an artificial inflation of the currency.

How is it, then, that these important factors tend to be ignored when wages increases are considered? For that they are ignored is obvious to every observer. Demands for increases of wages are of almost daily occurrence and, commonly enough, they are coupled with a claim for reduced hours or reduced prices. Wages on the railways have been increased by about £80,000,000 during the past four years, and on the top of that the concession of an eight-hours day will add a further £20,000,000 to the wages bill. Where is the money to come from, we ask, but, like jesting Pilate, we do not pause for an answer. The next day the public is clamouring for a reduction in railway fares, and the day after acquiesces in the addition of millions of pounds a year to the cost of coal. The coal position, indeed, grows increasingly serious, for coal is the mainstay of our industrial prosperity, it is the great asset upon which our commercial fabric is based. How, then, do we stand in regard to coal? In 1887 we produced 299 tons per worker at a wage cost of £52 per head. In 1914 the output per worker had fallen to 243 tons, while the wage cost had risen to £99. In 1918, during the great national crisis, the output had shrunk still further to 224 tons per worker at a wage cost of £197.

Again, the concession of a forty-seven hour week in the engineering and shipbuilding industries means, it is calculated, an increase of 5 per cent. in the cost of the finished products. And yet before the ink of the agreement is dry, before there has been an opportunity to see how the new arrangements will work, a demand is raised for a forty-four or even a thirty hour week. Surely it is high time that we recovered our sanity, and recognised that what we are doing can only have the effect of injuring those whom we design to help, of destroying, not reconstructing industry. Surely it is clear that whatever the solution of the problem of wages in industry may be, we shall not reach it along the present road. We are merely revolving in a vicious circle, and unless we can make up our minds to cut clear of the evil traditions of the past and the profligate timidity of the present, we shall have a rude awakening.

Wages, according to political economists from Adam Smith's day onwards, are governed by the laws of supply and demand, and the price

of the necessaries and conveniences of life. "What are the common wages of labour," says Adam Smith, "depends everywhere upon the contract usually made between these two parties, whose interests are by no means the same. The workmen desire to get as much, the masters to give as little as possible." Hence employers have organised themselves into associations, and workers have created trade unions, in order that they may have the necessary power to enforce their demands. The determining factor in each case has been the strength of either side, and the effective criterion of what wages ought to be has been the will of the strongest party. If employers are not strong enough to withstand a strike, if the workers have a sufficient fighting fund, wages are raised; if, on the other hand, the workers cannot hold out against unemployment and the spectre of starvation, the employers enforce their will. Strikes and lock-outs are recognised, not merely by employers and workers, but also by the Government, and, indeed, the whole community, as the proper method for settling industrial disputes; they are sanctioned by public opinion, and no alternative method has gained acceptance. And yet the theory that the only effective criterion of justice is what a man is strong enough to take and to hold, that might is right, strikes at the very roots of civilised society—indeed, of all social existence and of all religion. Might is the handmaid of right—not its master, and this must be true of all human relations, not merely of a selected few. The claim by Germany that the only criterion of her rights in relation to other nations was what she was strong enough to take and to keep, has led to the greatest war in history, and we are living in a fool's paradise if we suppose that a principle which leads to disaster as between nations will not have the same results as between the rival sections of a single community. Indeed a community presupposes a common purpose, which is greater than the rival interests of individual groups, and unless the claims of one section are determined in the light of the good of the community as a whole, society becomes a disorganised rabble, and is resolved nto an aggregation of dens of thieves.

Industry is one of the last strongholds of "King Might," and even here his sway is not as unquestioned as it was. The State tends to intervene more and more, and to determine in ever-increasing measure for the common good the conditions under which industry shall be carried on This is its legitimate function, and one by no means to be confounded with State trading, which is indeed inconsistent with the due exercise of impartial supervision in industrial matters. The development of State trading with which we are threatened will, it is to be feared, deal a shrewd blow at the authority of the Government as the final arbiter on industrial conditions, for being itself a trader it will lose its impartiality, it will become a judge in its own cause, and will think as an employer of labour, not as the representative of the community.

But although, as I have said, the State tends to intervene more and more in industrial matters, and to determine the conditions under which industry shall be carried on, its authority is still effectively disputed in the settlement of the wages problem, or, to put it more broadly, the problem of the relation between wages and profits. And indeed, so long as both employers and workers refuse to recognise the authority of the State, and claim that the profits and wages which each side respectively is strong enough to enforce are those to which they are entitled —that might is the only criterion of right— so long, too, as the general public acquiesce in, if they do not actively endorse this view, the State cannot assert its rights. Government is obviously impossible if, and in so far as the great majority refuse to be governed, and we can but drift towards the rocks until the public consciousness is awakened, remembering the while that the longer it is delayed the more rude will the awakening be.

The wage problem in industry, which is the subject of this paper, is in essentials simple to grasp; it is, as I have said, the problem of the division of the proceeds of industry between labour and capital. How are we to ensure that neither the capitalist nor the worker gets too large a share of the products of industry? How are we to provide that one class of labour does not get too much in relation to another? How are we to secure that the consumer is not robbed by the exaction of too heavy a toll for services rendered? How is the cake of communal wealth to be divided up fairly amongst the various claimants? The old-fashioned system of a general scramble, in which each fought for his own hand and the devil took the hindmost, has worked exceedingly ill, and even before the war signs of an approaching storm were not wanting. To-day everyone recognises that some change is necessary. We talk eloquently of co-operation; we put our trust in round-table conferences and Whitley Councils; but neither side is willing to surrender a tittle of its so-called

rights—the right to keep whatever its strength enables it to acquire. No tinkering policy of compromise can bolster up this system for long, because it is fundamentally unsound. A radical change is inevitable.

So strong is the feeling of unrest in the industrial world to-day, that the view is gaining ground that the present system cannot be mended, and must be ended. A cry has been raised that the wage system is a form of slavery which should not be tolerated in a free community. "Down with wage slavery" is a cry which appeals to the heart, if not to the head, of many a man and woman to-day. The only element of truth in the cry is that mankind is condemned to live by the sweat of its brow; for nobody can truthfully contend that labour has no voice in the determination of wages, the conditions of labour, the choice of employment, the essentials, in fact, of industrial life; its voice is at least as effective as any other, and it is absurd to compare the condition of the modern wage-earner with that of a serf under the feudal system. It would be a mistake, however, to ignore the strong opposition that exists to "wagery," and to imagine that it is merely the fantasy of disordered brains. Exaggerated it may be, misapplied even, but there must be some real injustice lurking unseen in the background to have given strength of late to this emotion which the present wage system arouses in the minds of many.

The root cause of the antagonism, I suggest, lies in the fear of capitalist domination. It is the dread lest ultimately capital may prove too strong for labour and enforce to the uttermost the doctrine by which industry is governed that might is right. The war with capital, in the minds of these people, is a war to the knife, and must be carried to the point of extermination—for there can be no compromise, given the right of capital (or indeed of labour) to exact whatever it is strong enough to demand. But even assuming (and I for one strongly dispute it) that the fear of capitalist domination is justified, will the alternative proposals of the syndicalists and guild socialists who denounce wage slavery provide a practicable solution? The guild socialists propose to divide the industries of the country into a number of watertight compartments, each of which will be run on democratic lines by the workers themselves, whilst they will all be co-ordinated by means of the guild congress. There would thus be a number of industrial states with wide and independent powers, but federated for common purposes. The members of each guild would be paid—not wages—but a share of the joint product of their labour. The essential feature of the scheme (for I must not weary you with details) is that each industry will be a monopoly controlled by the workers themselves. True, the guild socialist differs from the syndicalist in proposing joint committees of consumers' guilds and workers' guilds, of guild congress men and members of Parliament, but, failing agreement, the power of ultimate decision is always to rest with the guilds—the right to strike is to be their inviolable prerogative. Should we not, then, under the guild system merely have changed King Log for King Stork? Would the community be any better off under the *régime* of such a monopoly than it is at present? The competition between one manufacturer and another and between labour and capital at least has this advantage that the consumer reaps the benefit of the lowest possible prices. Competition is the very life-blood of the modern industrial system, and although its absurdities doubtless require trimming, it cannot be wholly eliminated without disastrous results. To substitute for it a series of democratic monopolies is to court certain destruction. For it will be the workers themselves who determine the hours of work, the types of goods to be manufactured, the price to be paid. Better surely a balance of power between labour and capital even, as at present, than the domination of one or other. If the worker is right in his dread of the domination of the capitalist, the community is surely equally justified in hesitating to submit itself to the tender mercies of a number of democratic industrial monopolies.

Thus the attempt to abolish the wage system by the methods of syndicalism or guild socialism fails to safeguard the interests of the community as a whole, because it implies that each industry will be run in the interests of the workers and not of the community.

Another suggestion, however, which merits careful attention has been put forward as the solution of the wage problem. It is urged that, since the rivalry between capital and labour has led to disastrous consequences, the true solution lies in marrying the interests of the two by means of profit-sharing or co-partnership. At first sight the proposal is very alluring, for whilst assuring a reasonable wage to the workers and a reasonable return to capital as a first charge on the proceeds of each industry, it secures that the balance shall be fairly divided between the two.

But, although the principle of co-partnership is doubtless applicable in certain cases, there are, it seems to me, certain fatal objections which prevent its general adoption.

In the first place, if it is to succeed, the capital employed must be high in relation to the wages. If, for example, to assume an extreme case, the capital in any given business were £1,000 and the wages £100,000, it is obvious that, without gross profiteering, the share in the surplus profits accruing to labour would be insignificant. If, on the other hand, the capital were £100,000 and the wages only £1,000 the prospects of a substantial dividend to labour would be rosy.

In the second place there would be glaring inequalties amounting to injustice, as between one business and another. A collier working on a rich mine would receive far more than his fellow-worker on a poor mine, although the type of work done by each and the hours of labour might be exactly the same. This would cause a rankling sense of injustice, and in the end probably men would pay a premium to work on the rich mine just as the porters and head waiters at big hotels are said to pay a premium in consideration of the tips that they expect to receive. It is really unreasonable to expect that a worker in a struggling concern should be paid less than one engaged by a rich firm, and in actual practice I suspect that it would be found necessary for the less successful firms to guarantee a bonus equivalent to the share of the profits accruing to the workers in the more prosperous ventures. Otherwise a firm which had met with reverses would find that it could only attract the least efficient workers at a time when efficiency was most needed to save it; or it might even find that it was unable to obtain the necessary labour.

It would be easy to multiply the practical difficulties that would arise if co-partnership were adopted on a wide scale, but I will confine myself to one further point the importance of which cannot be ignored. The tendency of modern industry is towards big organisations, and this applies to the world of labour just as much as to capital. No doubt this movement has its drawbacks, but it promises even greater compensations in the direction of heightened efficiency, economy of production, and the greater stabilisation of employment.

On the side of labour big combinations are an advantage, not merely because they strengthen the bargaining power of the workers, but also because they break up the watertight compartments into which many small trades have drifted. Interchangeability of labour is an essential of modern industry for, owing to the changes in methods of manufacture which new mechanical inventions are daily introducing, work cannot be stereotyped in the hands of any given trade. The workers must be ready to change their methods and even their trades if we are to secure economy of production. Consequently the demarcation disputes which have always been one of the bugbears of industry will tend to increase as our methods improve unless there is more elasticity as between one trade and another. It is really absurd that one trade should claim the privilege of punching a hole in a ship's plate while the prerogative of drilling a hole in the same plate belongs to another trade. This interchangeability can best be secured by broadening the basis of trade unions.

Similarly trusts and cartels, provided they are properly controlled, will play a greater part in securing increased efficiency and cheaper production.

If then the organisations of labour and capital expand, and in some industries become all-embracing, there is a real risk that under a co-partnership scheme the community may be exploited. If, for example, the coalminers and the coalowners were to form one big co-partnership organisation, the interests of both might be satisfied; but the general public would suffer. In fact, fundamentally, the same objection applies to co-partnership as to the guild system or syndicalism, namely, that it assumes that industries are to be run primarily in the interest of those engaged in them, and not in the interest of the whole community.

I do not believe, therefore, that any satisfactory scheme can be devised for eliminating the wage system, save in exceptional cases which are of small moment in the consideration of the problem. If, then, there is no alternative to the wage system, what can be done to remove the objections that are brought against it? I do not propose to discuss here the relative merits of time rates, piece-work rates, and premium bonuses, partly because I should make too great a demand on your patience, and partly because none of them can solve the fundamental objection which is brought against the wage system—I mean the fear of capitalist domination. So long as industry is organised on the principle that the criterion of what either capital or labour are entitled to have is what their strength enables them to acquire, so long as the keynote

of industry is that might is right, each side will naturally fear domination by the other.

But the domination of either, or both, would be a disaster to the community as a whole, just as the present rivalry between the two opposing forces is a disaster. The mistake lies in isolating the interests of all three—capital, labour, the community; in the selfishness, to use a plain term, which causes both capital and labour to organise in their own interest against each other and against the community; in the false ideal which enthrones King Might and banishes Justice. Clearly both capital and labour are as necessary to the corporate existence of a community as are the head and hands to the human body. Each has its separate function to fulfil, and each is entitled to its reward. But both work for a greater whole, and neither may claim to dictate what their reward shall be. The community, through its chosen representatives, should exercise its right to regulate the demands of both and, unless anarchy is to ensue, both must be prepared to accept loyally the verdict of the constituted authority. All wages are a question of relation. What matters is, how much a carpenter, for example, earns in relation to a boiler-maker, a school teacher, or a parson; how much of the general wealth a capitalist gets in relation to a man whose only assets are his brains and his hands.

The demands, therefore, of the wage-earners in each trade and each industry cannot be settled in isolation from each other, or independently of the claims of capital. For an increase in wages in one trade involves an increase in others, and in time these increases react on capital, which requires a higher rate of interest. While, therefore, the organisations of employers and employed in each industry should be responsible in the first instance for negotiating all wages problems, the Government should exercise the right of reviewing all decisions from the wider standpoint of the general interest, and should regulate both the profits of capital and the wages of labour in order that a due proportion may be observed. Governments exist primarily in order to do justice as between one individual and another, between one section of the community and another. They have surrendered this duty in the past, so far as industry is concerned, owing to the false teachings of political economists, who succeeded in substituting the laws of supply and demand, and of unrestricted competition, for the moral code. But ultimately, all industrial questions, as well as all the other questions affecting human relations, resolve themselves into moral problems, and how far we succeed in solving these questions depends on the degree of moral consciousness to which the community has attained. Failure, therefore, to solve our industrial problems implies a moral failure on our own part, and it is as well to recognise it frankly, and to realise that the most profound and exhaustive research will never find a substitute for the moral code which is the mainspring of all human societies. The words "Seek ye first the Kingdom of God, and all these things shall be added unto you," have become a commonplace of literature, and are probably endorsed in church on Sundays by innumerable congregations as sound doctrine, but inapplicable to the affairs of everyday business life. Once back in the work-a-day world common sense prompts us to murmur :—

"Ah! take the cash and let the credit go
Nor heed the rumble of a distant drum."

But is it really common sense?

DISCUSSION.

Mr. E. W. Mundy (Secretary, Labour Co-partnership Association), in opening the discussion, said he thought the author, in speaking of labour co-partnership, had looked very far ahead to a time when the whole of an industry would be conducted on the lines of labour co-partnership. In attacking that system, the author had done so chiefly by imagining that there was a trust or combine of the whole of a trade, and saying that then there would be likely to be a combination between the capitalist and the employee, who were sharing profits, in order to mulct the consumer. Personally, he did not quite follow that argument, because what was there in that combination between the capitalist and the labourer which would enable them to raise prices? Why should the fact that the capitalist was fighting against the employee, rather than working with him, give him less power of putting up his prices? He failed to see how the workman could affect the power of the employer to raise prices. Co-partnership as practised at the present time had brought about a much better feeling between the employer and the employee. Perhaps one of the best examples he could give was that of the South Metropolitan Gas Company, the Chairman of which, Dr. Carpenter, in a recent speech, emphasised the extremely good relations which had existed between his workmen and himself and the Company during the time of the war, and said that those relations were chiefly due to the co-partnership scheme that existed. He would like to ask the author a question on the earlier part of the paper, where he said that an industry could not be carried on without renewed

capital—without putting fresh capital into the business. He took it that every business—at any rate every successful business—put fresh capital in every year, which they called reserves, and every stable business built up reserves for itself; but the author seemed to hint that the only way of getting fresh capital was to obtain it through the individual savings of shareholders, who were given higher rates of interest than were necessary in order that they might have some money left to reinvest in the business. He would suggest that there was a possible way out of the difficulty, namely, the building up in the business of the unnecessary profits of that business—by "unnecessary profits" he meant those profits which need not be distributed in order to attract fresh capital from outside. The author also stated that if the rates of interest were lowered—and he took it the author meant the rates of interest over a wide area—money would no longer be invested. He thought that was a very serious proposition at the present moment, because most people recognised that real wages had to be raised in industry above their pre-war level. Now if wages, prices, and interest on capital were all raised, the position would be the same as it was before. It seemed to him that one of those three would have to remain where it was, and that capital would have to be content not to double its rates of interest if prices and wages were doubled, which meant that the interest on capital would be reduced if real values were considered. He did not think that would prevent capital from being put into an industry, because the rate of interest would be reduced over the whole area of industry, and people would still put their capital into the business from which they obtained the greatest security and the highest rate of interest as compared with other businesses. Of course, if people could get a better rate of interest and better security abroad he supposed they would invest their capital there, and then the only thing for a company in this country to do would be to save up in its own business, and not trust to fresh money being put in by individual people.

Mr. Neville Priestley, after congratulating the author on his admirable paper, said he wished to challenge him on two points. The author stated that co-partnership would be impossible on a large scale because there would be industries where one factory was doing well and labour therefore received its share of large profits, and where another factory was doing badly and labour received only small profits. That state of affairs, the author contended, would create discontent amongst the employees of the factory that was doing badly, and they would demand something to put them on an equal footing with the employees of the factory that was doing well. That was true to a certain extent, but it brought out one very mportant consideration which this country had largely lost sight of, namely, that the people of this country were too much attached to "one-man businesses" and were too much inclined to bolster up weak concerns, instead of allowing them to die out and the larger concerns to develop. If prices were to be reduced it was obvious that the more various businesses were concentrated and their production increased the larger would be the output of the unit, the smaller would be the profit required on each unit to pay a return, and therefore the larger would be the general prosperity of the nation. A great deal of the trouble in this country was caused by maintaining moribund or semi-moribund businesses. The second point he wished to refer to was the author's contention that if labour and capital combined in a great scheme of co-partnership the consumer would suffer. He challenged that statement, because at the present moment there were in this and other countries large combinations of capital, that was to say, combinations of those who were controlling industries. They controlled the price that was charged to the consumer, and, if they did not oppress the country —he did not say that they had not done so, but that did not affect the argument—the position would be no different if there was a further combination between capital and labour in the nature of co-partnership. He was in entire agreement with the author that the Government ought not to manage businesses themselves. They ought to be the arbiter between the three parties—labour, capital, and the consumer; and the Government ought to step in and insist that, while capital was paid its full price and labour was paid its full price, the consumer was not exploited by either. There was another way out of the difficulty, *i.e.* to divide the profits not between capital and labour, but between capital and labour and the consumer, which was the method adopted by the South Metropolitan Gas Company. That Company could not charge the public a higher rate without reducing the interest on their own capital or the bonus they paid to their employees, and if they wanted to pay a higher rate of interest to the shareholder or a bigger bonus to the employee they had to reduce the rate to the consumer, so that the benefit was shared by all three parties. That principle could not be applied to ordinary trade, because it was impossible to get hold of the consumer after the goods had once left the factory, but the result could be obtained by carrying out the method that had been introduced during the war and that bore the very obnoxious name of "excess profits tax." Whatever profits were made over and above the amount necessary to pay labour its wages, and capital a reasonable interest on the money invested, should be divided between the labourer and the capitalist and the consumer—that was to say, the State on behalf of the consumer—and the consumer would reap the benefit by having his taxation generally reduced. While there were difficulties in the way of the general adoption of co-partnership, he was

quite sure that until the workman and the employer could be brought on to the same basis—and co-partnership did not mean only division of money but also division of responsibility and mutual interest in the general management of a concern—the claims of labour would continue to be as irresponsible as they were now and capital would never be on friendly terms with labour, but each would be trying to snatch something from the other or to keep back something from the other, and the conditions would always be as unsatisfactory as they were to-day.

The Chairman (Sir George Ranken Askwith, K.C.B., K.C., D.C.L.) said the meeting owed a debt of gratitude to the author for the care and trouble he had taken in dealing with the complex question which he had attacked. He was rather struck by the fact that the author came to the conclusion that the Government must do a very great deal in the matter. There were certain limits to what a Government could do. He was quite sure that in many parts of the country the interference of the Government and of the bureaucrats appointed by the Government had not been very popular during the last few years. Under the stress of war people acquiesced in the position, but it seemed to him rather a large order to lay it down, as the author did, that "the Government should exercise the right of reviewing all decisions from the wider standpoint of the general interest, and should regulate both the profits of capital and the wages of labour in order that a due proportion may be observed." The Government could not by a stroke of the pen or an Act of Parliament establish any of the theories which the author mentioned in order to throw out, such as syndicalism or guild socialism or any of the other "isms" that had recently been put forward. The duty of the Government was rather to exercise the power of amelioration, and, although they might make experiments, as a large employer of labour themselves, in certain directions that might be indicated to them, he doubted whether they could by an Act of Parliament destroy the whole system of the country and build up another. Neither did he think they could interfere continuously between employers and employed, or put before people who must necessarily be at a desk in London agreements which had been made between employers and employed, with a view to their being altered in the interests of the consumer. For years, no doubt, the Government had exercised their powers of amelioration. He noticed a very considerable difference in what had happened in this country since the years 1911 and 1912, when there was a great disturbance in the country. He noticed, too, that employers and employed had organised themselves in a far more effective manner than at that time, and that both were far more inclined to pursue a constitutional course in the attitude they adopted in any disputes they might have. But, although that amelioration had taken place, and there were very great schemes before the country for further amelioration, that had not prevented a considerable amount of industrial unrest. Why was it that the country was so impatient? The author said the chief cause was fear, and up to a certain extent he agreed with that; there was fear, and that fear was coupled with suspicion engendered by disputes extending over many years, and by disputes which were on the eve of breaking out but which were kept in the background during the war. That fear might take certain forms. There was always the spectre of unemployment, both for a man himself and for his colleagues. There was also a strong feeling that if there was to be increased production the results of that production should not go entirely to the capitalist class, and that the capitalist should give up more than he had in the past to the wage-earner, in order that the wage-earner might have a better chance in life. There was a fear of going back to exactly the same conditions as those that existed before the war, and there was also a fear that the present high prices might continue, and that the wages paid might not be sufficient to meet the cost of living if wages, which had been greatly enhanced during the war, should by any means be reduced. There was also another cause for the impatience manifested. "Liberty, Fraternity and Equality" was a "catch-call" at the time of the French Revolution. It was not the words themselves so much as the misapplication of them that might sometimes be in the wrong, and there was no doubt now in the country a feeling that there should be more liberty, in the sense of a better social, economic and political position for the masses of the people, that there should be more equality between class and class, and that what was given to one should be given to another. Sectional advances in wages that had been given in certain places during the war had always been a source of great trouble. During the war there had been a great desire manifested for equality—equality in rationing, in conscription, and in the war wages that had been given to different sections of the community. That principle had been carried out by the large organisations which had been formed, in that such organisations were asking for increases in wages and reduction of hours for every one of their members alike. The efforts of those organisations were largely directed to ensuring that if there was to be mass production—of which the country had shown itself to be capable during the war—the results of that mass production should be distributed in a different manner from that in which they were distributed before the war, and that if there was no mass production, no increased production, still the results of what production there was should be distributed more equitably. Those were views held by a great number of the workers of this country, and they were views that the country would have to meet. He did not believe anyone thought that the Golden

Age of plenty and idleness had really come, but the question of the distribution of the wealth of the nation, both what it was and what it might be in the future, was the question that was now before the country.

Mr. W. L. Hichens, in replying to the discussion, said he quite agreed with the Chairman that the distribution of wealth was the main problem with which the country had to deal, but how was that improved distribution to be brought about? Was it to be brought about by a free fight between one section of the community and the other, or was it to be brought about by some reasoned method? He also agreed with the Chairman that he was throwing a very great responsibility on the Government in suggesting that the ultimate responsibility for determining the relative distribution of wealth as between one section of the community and the other rested on the Government. It was, however, a responsibility that the Government would have to face at some time or other, and it was because they had not faced it in the past but had shirked it during the last century that the country was in the state in which it found itself in to-day. If the Government undertook the task at the moment they would fail completely, because they had not got the community behind them. The community was not educated up to that pitch to-day, but it would have to be educated up to it one day, because the country could not stop short half-way. It could not say: "We quite agree that there should be a better distribution of wealth, but we can suggest no means whereby that can be brought about except a free fight between the parties concerned," which was really the only alternative. Surely the community had got to tackle the problem. Supposing the transport workers, the railway workers, and the miners all combined together to obtain very much reduced hours and very much increased wages at the expense of the whole community, that situation would have to be dealt with in some way or other. It was no good saying that the employers and the men must negotiate. The employers might not be strong enough to hold their own, or it might be that, in the effort to do so, there would be such a dislocation of the convenience of the public that it would not be possible. He might illustrate his point in the following way. Suppose that A walked into B's house, and said, "I see some very nice silver on your sideboard and I propose to discuss with you how much of it I shall take." If A were not very eloquent a compromise might be arrived at and he might take only a small proportion. On the other hand, if he were strong enough he might take it all. But there would not be any justice in that at all, and it was the duty of the State to see that he did not take anything that did not belong to him. In the same way it was the duty of the State to see that neither the employers nor the workers took what did not belong to them. Men could pillage and could commit an act of injustice if they clamoured for more wages or more profits just as much as if they went into another man's house and stole his goods. With reference to Mr. Mundy's remarks with regard to capital, Mr. Mundy suggested that capital would have to be contented with a good deal less than it had had in the past, if indeed it had not to be contented with the heartfelt sympathy of the community, and he indicated that if the worst came to the worst an established business might be able to get on by means of reserves which it might possess at the time or might create. But the trouble was that those reserves were in themselves capital; they were savings; they were the capital belonging to the shareholders of the company, and nobody was going to create reserves to put into a business which had to be contented with "heartfelt sympathy." People wanted interest on their capital, and if they were not given enough interest to satisfy them they would invest their money elsewhere. One of the great features of the war had been the growth of the small investor class. About £600,000,000 had been collected during the war from the smallest class of investors, and, although that was partly due to the spirit of patriotism which had animated everyone during the past few years, that did not alter the situation. Anyone who had done any work in connection with war savings societies would agree that people had to be convinced that it was worth their while financially to invest their money in war bonds or war savings certificates. The small investor had the choice put before him of going to a cinematograph theatre or having a good dinner, or saving his money for a rainy day, and if he was told that he could either have his dinner or put the money into war bonds, in which case it might be confiscated by the community, he would probably choose to have his dinner. It had to be made worth while to the individual—the human being—to save his money, and the smaller the investor the more the inducement had to be. If people told a man, as they did at the beginning of the war, "Spend 15*s.* 6*d.* on a War Savings Certificate, and in five years' time it will become £1," he would prefer to "take the cash and let the credit go," and one could not blame him for that. Rates of interest had had to be raised during the war simply because that was the only way of obtaining the money that was required. The cost of nearly everything had gone up by 100 per cent. An ordinary business had a depreciation fund, and wrote down its machinery during the lifetime of that machinery, but a machine that previously cost £100 would now cost £200 or £300. That extra money had to be obtained from the pockets of the saving public, and he thought it was a most dangerous doctrine to suggest that capital had got to be contented with whatever it could obtain, because it would not—it would cease to exist at all. With reference to co-partnership, he thought it did not really go to the root of

the matter, although he did not want to discourage any experiments that might be tried in that direction. Mr. Priestley himself quite rightly pointed out that there might be a strong combination, practically a monopoly, in any given trade, and he (the speaker) did not agree with Mr. Mundy in thinking that there was no likelihood of such an event taking place in the near future. Assuming such monopolies did exist, Mr. Priestley said that the State would have to step in if the co-partnership scheme in force did not work fairly. If the State did so, it would have to determine whether too much was being paid to the workers in one trade in relation to other trades; therefore the State would have to determine what the wages were to be and on broad lines what the profits were to be, in the way that he had indicated in his paper. Wages disputes took place not merely between capital and labour, but between one section of labour and another, and he did not see how co-partnership was going to determine, for instance, in the shipbuilding industry, how much a carpenter was to have in relation to a riveter. One section of workers obtained more money than another if they had a strong trade union behind them, without reference at all to their skill. Such things should be determined not by brute force, but by some kind of impartially constituted tribunal, and unless public opinion could be educated up to that point, the country would remain in the quagmire in which it found itself to-day.

On the motion of the CHAIRMAN, a hearty vote of thanks was accorded to Mr. Hichens for his interesting paper, and the meeting terminated.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

The Equipment of the Wool Industries.—State control has at last provided the wool industries with a more dependable set of statistics than they ever knew before, and it may be hoped that the level of exactitude now reached may be maintained after the control has ceased. The official purchase of British wool removed in the first season a misconception of the weight of the British clip. Full industrial statistics are still to be published, and it may be believed that they will improve understanding, for it is many years since any comprehensive figures were collected. Information now available shows that there are a total of 2,934 machine combs in the United Kingdom. Ré-combing machines are included in the count, but their numbers can hardly be great. There are 3,066,000 mule and frame spindles working upon woollen yarn, and it is safe to estimate that not more than a few thousand of these are frames. The worsted spindles number 3,459,200, and there are 121,551 worsted and woollen looms. To accept the Home Office figures relating to 1904, it appears that an increase has taken place of some 14 per cent. in woollen spinning plant, 18 per cent. in worsted spinning, and 16 per cent. in the number of looms. The particulars cannot indicate the increase in productivity occasioned by the substitution of new machines for old, the faster driving of plant of all kinds and the introduction of more efficient types. It would be hazardous to say what these hidden improvements amount to upon the whole, but the gain upon this score might be put at 10 per cent. Pursuing a conservative policy all round, the combined increase in efficiency of output and in the size of the mechanical equipment might be said to suggest at least 25 per cent. advance upon 1904. It is, of course, not the case that all the 121,500 looms have been working of late, and much spinning machinery has been kept waiting for material or for workers.

Value and Volume.—The values of our cotton exports are far greater than ever, and in terms of value we have been doing from one and a half to two years' business in one. In terms of volume we have been doing about six months' business in a year. The deficit in quantities has been piling up bewilderingly. Instead of 210 million lb. of yarn, as in 1913, our export customers got 101 million, and instead of 7,075 million yards of cloth they got 3,695 million. It is usual to calculate upon a steady increment of 2½ per cent. from year to year, and this fraction gives a great deal to live upon. A progressive decrement covering five years, and amounting in the end to a round 50 per cent., manifestly leaves room for a revival, although it is true that Lancashire never sold 7,000 million yards of cloth with 32's Twist at 41 pence per lb. Prices are an obstacle, but the prices of raw commodities are not necessarily the greatest. There have been months in the past year when the ordinarily exiguous margin between the cost of cotton and the sale price of yarn has amounted to substantially more than the existing cost of the raw material, and to more than spinners were wont to get for their complete product. As the market could pay the prices, and as the Government took most of the proceeds, it would be superfluous to blame spinners for this extraordinary state. The fact that raw material is not the main item, gives its own warning to those who count upon reduction in that article to bring lower prices for goods. Palpably, manufacturing profit margins have further to fall than has raw material. The public will gain in their capacity of consumers what the State will lose in excess profits duty, and the industry upon its reduced footing will indefinitely multiply its opportunities of maintaining full employment.

Joint Enlightenment. — Workmen are not necessarily to blame for the failure of employers to instal improved machines, but at least they do not encourage enterprise upon the part of their employers by neglecting to give new machines the best chance. Employers, upon

the other hand, are not unstintedly to be praised for introducing isolated new machines when the necessities call properly for new and large-scale plants. It is not worth while to pretend that there are not faults upon both sides, and, the admission having once been made, the handsome course is to treat those faults in company. Some such reasoning, it may be guessed, animates the decision of the Brighouse Silk Spinners' Association to hold lantern lectures for attendance by both masters and men. Slides will be shown to exhibit the types of machines successfully used in other countries, and to demonstrate the results gained. The intention is to bring all concerned to the point of valuing unaccustomed processes upon their merits, and the effort is at any rate one to be considered.

Daily Output.—Perhaps there is a force in human nature driving those who over-exert themselves one day to compensate by under-exertion upon another. Manufacturers, at all events, do not find their workpeople eager to maintain their top speed throughout the week, and high wages do not tempt them to keep it. One who employs girls notes that their ambition is 35*s*. a week. On Mondays their zeal is sluggish, on Tuesdays they are preceptibly more keen, and on Wednesday and Thursday they make half the week's pay. Friday is spent perfunctorily if the ideal amount has been achieved, and Saturday is hardly even nominally a working day. The rise and fall may be less evident in occupations where individual initiative is less free, but traces of the same disposition to be slow in warming to work and quick in relaxing once expenses have been covered is noticed by many. The experience is evidence to them that improved wages do not lead inevitably to stimulated production.

CORRESPONDENCE.

THE GOVERNMENT AND THE ORGANISATION OF SCIENTIFIC RESEARCH.

The interesting paper recently read before the Society on the above subject by Sir Frank Heath showed that, during the war, valuable help was given in connection with research in applied science. It would be a grave mistake, however, to assume that a mere continuation on the lines which have hitherto been followed will suffice to restore our industrial position in peace time. In the writer's opinion it will be necessary to adopt a much bolder policy, and to extend greatly the scope of the Department of Scientific and Industrial Research. The weakness at present is that fundamental researches, for the conducting of which a large financial outlay is required, are compelled to languish for want of funds. As an example, electric furnace research on an industrial scale is practically at a standstill in this country, as the cost of equipment and upkeep would run into some thousands of pounds. In my recent Cantor Lectures on "High Temperature Processes and Products" I pointed out that America had a monopoly of the trade in artificial abrasives, made in the electric furnaces of Niagara, in spite of the fact that electric power is quite as cheap on the Tyne. M. Jean Escart, in his recently published book on "Electric Furnaces," has stated that "the whole future of the chemical and metallurgical industries of France depends upon the establishment of research centres, in which electric furnaces of sufficient size to gauge commercial possibilities are installed." This is equally true of England, and yet no individual or body is to be found willing to take the initiative, owing to the cost. The potential wealth of the electric furnace is infinitely greater than that of the aniline dyes about which so many tears have been shed, and upon which so much money has been spent. Unless prompt action is taken, it is safe to predict that we shall soon be dependent on America for our higher refractories. In this, and in all cases where the expenditure involved is large, the research should be initiated and financed by the Government in the public interest. The official Government mind in the matter of expenditure was made clear in the remarks of Sir Robert Morant. It is the old pre-war attitude, which, if persisted in with respect to scientific research, will push us back to pre-war conditions. If we are to make our industrial position secure, nothing but a generous financial attitude towards research will suffice, and the sooner this fact is realised the better.

CHAS. R. DARLING.

OBITUARY.

JUDGE WILLIAM DENMAN BENSON, LL.D.—Mr. William Denman Benson, County Court Judge of Circuit 13, which includes parts of Derbyshire and the West Riding of Yorkshire, died at his residence in London on the 19th inst., at the age of seventy.

The son of General Henry Roxley Benson, C.B., he was educated at Eton and Balliol College, Oxford. He was called to the Bar in 1874, and joined the South Wales and Chester Circuit. A few years later he was appointed Revising Barrister and Counsel to the Post Office, and in 1907 a County Court Judge. In his early days he was a well known athlete: he was president of the O.U.B.C., and rowed in the Oxford and Cambridge Boat Race in 1868, 1869, and 1870.

He had been a member of the Royal Society of Arts since 1911.

GENERAL NOTES.

LIQUID FUEL.—An account is given by M. A. Guiselin, in *Mémoires de la Société des Ingénieurs Civils de France*, of the methods of obtaining and

preparing the marketable liquid fuels from all sources, such as oil from wells, from shale, from coal, from lignite and peat. The recent steps taken in France to improve her own sources of supply are considered in detail. As an indication of the importance of the matter the efforts made by Germany during the war to obtain supplies of oil from Galicia, Rumania and Baku are described. In France there are indications of oil from wells, but the matter has not been followed up to any extent; better progress has been made in Algeria. There are extensive deposits of oil shales in France, which are on the eve of being exploited. A special horizontal cylindrical retort has been devised containing a slowly rotating screw, which pushes the shale from one end to the other, and is said to give an excellent yield. The temperature does not exceed 500° C. and the spent shale, which contains a certain amount of carbon, falls from the retort into a producer, where it makes ordinary producer gas. The extraction of oil from bituminous coal is described, and some experiments are quoted showing the importance of removing the gas and various oils from the retorts at the various stages as they are produced, so as not to expose the light oils to high temperatures. The gas is recirculated, and by the consequent reduction to partial pressure the vaporising of the oil takes place at a lower temperature than without recirculation, and thus the same quantity of oil is obtained at a temperature of 400° as otherwise would require 500°. The results of experiments in this connection are given in tabular form. The methods of obtaining oil from coal dust, lignite, peat, kernels of olives and other fruit are described and exemplified by a considerable amount of data. There is also a chapter on the production of alcohol from various grains.

SOUTHAMPTON DOCKS.—Some interesting figures relating to the traffic passing through Southampton Docks during the war are given in *Ice and Cold Storage*. From the time of the dispatch of our original British Expeditionary Force up to the signing of the Armistice, some 59,000 special trains ran over the system of the London and South-Western Railway Co. (who also own the docks) to alongside the transports, carrying 500,000 officers, 20,000,000 men (including wounded and "leave" men), 1,500,000 horses, 11,000 guns, 115,000 vehicles, nearly 500,000 trucks of stores and baggage, 38,000 bicycles, and 2,166 tanks. The total number of trains include about 10,000 ambulance trains. To assist in this marvellous traffic a Channel train-ferry was instituted, a special railway and pier being constructed by the Royal Engineers (Inland Waterways and Docks Section) to accommodate the specially-constructed vessels, which were built on the Tyne and the Clyde, each having a length of 362½ ft. and a displacement of 3,654 tons, the average daily load being about 1,000 tons.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

MARCH 5.—B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present." PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, will preside.

MARCH 12.—WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

MARCH 19.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity." The Right Hon. LORD MOULTON, G.B.E., K.C.B., F.R.S., will preside.

MARCH 26.—ARNOLD HARTLEY GIBSON, D.Sc., M.I.Mech.E., Professor of Engineering, University College, Dundee, "British Engineering and Hydro-Electric Development. (The Training of Engineers.)"

APRIL 2.—W. NORMAN BOASE, "The Cultivation and Preparation of Flax, and the Linen Industry." The Right Hon. LORD COLWYN will preside.

APRIL 9.—LEONARD ERSKINE HILL, M.B., F.R.S., "Housing and Infant Mortality."

APRIL 30.—SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems."

MAY 7.—JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 14.—H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

MARCH 6.—W. R. GOURLAY, M.A., C.I.E., I.C.S., "The Need for a History of Bengal." The Right Hon. LORD CARMICHAEL, G.C.S.I., G.C.I.E., K.C.M.G., will preside.

MARCH 13.—D. T. CHADWICK, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission." The Right Hon. LORD INCHCAPE, G.C.M.G., K.C.S.I., K.C.I.E., will preside.

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as

affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

MARCH 4.—PROFESSOR JOHN CUNNINGHAM McLENNAN, O.B.E., Ph.D., F.R.S., Scientific Adviser to the Admiralty, "Science and Industry in Canada." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 27.—SIR EDWARD DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

Dates to be hereafter announced:—

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. N. SPENCER WILLIAMS, "The Hawaiian Islands and their Industries."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." Three Lectures.

March 10, 17, 24.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 3 ... Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. The Head Master of Winchester College, "The Vocation of a Teacher."

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Mr. A. Mansell, "The Future of Our Live Stock Industry."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. A. R. Ling, "Refractometry and its Applications in Technical Analysis." 2. Mr. F. Esling, "Notes on the Setting Time of Portland Cement." 3. Dr. G. H. J. Colman and Mr. E. W. Yeoman, "The Determination of Benzol, Toluene, etc., in Coal Tar and Similar Products." 4. Dr. P. E. Spielmann and Mr. F. B. Jones, "Estimation of Carbon Disulphide. A Critical Examination of the Various Methods usually Employed."

TUESDAY, MARCH 4...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Professor J. C. McLennan, "Science and Industry in Canada."

Röntgen Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor H. M. Lefroy, "How Silk is Grown and Made." (Lecture III.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. Dr. J. A. Murray, "Report on the Deaths in the Gardens during the Year 1918." 2. Mr. G. A. Boulenger, "On a Collection of Fishes from Lake Tanganyika, with Descriptions of Three New Species." 3. Miss Joan B. Procter, "On the Skull and Affinities of *Rana subsigillata*, A. Dum."

WEDNESDAY, MARCH 5 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. B. D Porritt, "The Rubber Industry—Past and Present."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Captain G. W. Brown, "The Lubrication of Motor Cars."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Dr. W. J. O'Donovan, "The War Time Experience of Factory Medical Officers and the Position of Factory Medicine under Peace Conditions."

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, E.C., 4.30 p.m. Professor A. W. Kirkaldy, "Industrial Changes Caused by the War."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. A. H. Thompson, "Some Notes on Colleges of Chantry Priests."

THURSDAY, MARCH 6...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. W. R. Gourlay, "The Need for a History of Bengal."

Royal Society, Burlington House, W., 4.30 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Miss S. Walker, "The Training of Teachers from the Child Study Standpoint."

Chemical Society, Burlington House, W., 8 p.m. Lecture by Professor J. W. Nicholson.

Britain and India, 7, Southampton-street, Holborn, W.C., 3 p.m. Inayat Khan, "Sufi Mysticism."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Aitken, "Rosetti." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Lieut.-Colonel L. Marsh, "The Future of Airships."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. G. L. Addenbrooke, "Dielectrics in Electric Fields."

FRIDAY, MARCH 7... Poetry Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m. Miss Marie Corelli, "The True Appreciation of Poetry."

Royal Institution, Albemarle-street, W., 5.30 p.m. Professor H. C. H. Carpenter, "The Hardening of Steel."

Philological Society, University College, W.C., 8 p.m. Mr. C. T. Onions, "Dictionary Evening."

SATURDAY, MARCH 8...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Spectrum Analysis and its Application to Atomic Structure." (Lecture I.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—February 28, 1919.

No. 3459. MARCH 7, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,459. VOL. LXVII.

FRIDAY, MARCH 7, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 10th, at 4.30 p.m. (Cantor Lecture.) WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." (Lecture I.)

WEDNESDAY, MARCH 12th, at 4.30 p.m. (Ordinary Meeting.) WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

THURSDAY, MARCH 13th, at 4.30 p.m. (Indian Section.) D. T. CHADWICK, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission." The Right Hon. LORD INCHCAPE, G.C.M.G., K.C.S.I., K.C.I.E., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

COLONIAL SECTION.

Tuesday afternoon, March 4th; Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair. A paper on "Science and Industry in Canada" was read by PROFESSOR JOHN C. MCLENNAN, O.B.E., Ph.D., F.R.S., Scientific Adviser to the Admiralty.

The paper and discussion will be published in a subsequent number of the *Journal.*

TWELFTH ORDINARY MEETING.

WEDNESDAY, MARCH 5th; PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Bhandari, J. G., M.A., Simla, India.
Doss, C. G. Narayana, Madras, India.
Garratt, Julius, Edgbaston.
Martineau, F. Leigh, M.I.Mech.E., M.I.A.E., London.
Owen, Captain Reginald Sankey, R.A.F., Stockport.
Roberts, John Edward, Alexandria, Egypt.
Robinson, Alfred E., Bombay, India.
Stevens, H. C. M., Wolverhampton.
Stubbs, Arthur, M.I.Mech.E., M.I.A.E., Smethwick.
Tekchand, Bakhshi, M.A., Lahore, India.
Wight-MacAdam, Robert, J.P., Dunbar, Scotland.

The following candidates were balloted for and duly elected Fellows of the Society:—

Benn, Ernest John Pickstone, C.B.E., Oxted, Surrey.
Billings, A. W. K., Barcelona, Spain.
Dewdney, William Gill, Derby.
Hargreaves, John William, Alderley Edge, Cheshire.
Johnstone, David Edward, Leicester.
Spencer, Douglas, B.A., Lieut. R.A.O.C., St. Ives, Hunts.
Tucker, William Edward, London.
Walker, Arthur, Whitehaven.

A paper on "The Rubber Industry—Past and Present" was read by B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

Thursday afternoon, March 6th; The Right Hon. LORD CARMICHAEL, G.C.S.I., G.C.I.E., K.C.M.G., in the chair. A paper on "The Need for a History of Bengal" was read by Mr. W. R. GOURLAY, M.A., C.I.E., I.C.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1919 early in May next,

and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 29th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K.C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
1868, Sir Joseph Whitworth, LL.D., F.R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul.
1874, Sir C. W. Siemens, D.C.L., F.R.S.
1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.
1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, Her Majesty Queen Victoria.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
1896, Professor David Edward Hughes, F.R.S.
1897, George James Symons, F.R.S.
1898, Professor Robert Wilhelm Bunsen, M.D.
1899, Sir William Crookes, O.M., F.R.S.
1900, Henry Wilde, F.R.S.
1901, His Majesty King Edward VII.
1902, Professor Alexander Graham Bell.
1903, Sir Charles Augustus Hartley, K.C.M.G.
1904, Walter Crane.
1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
1908, Sir James Dewar, M.A., D.Sc., LL.D. F.R.S.
1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.
1910, Madame Curie.
1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.
1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.
1913, His Majesty King George V.
1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.
1916, Professor Elias Metchnikoff.
1917, Orville Wright.
1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Tuesday, February 25th, 1919; Mr. W. A. S. Hewins, M.A., late Under-Secretary of State for the Colonies, in the chair.

The Chairman, in introducing the reader of the paper, said he remembered that, when the London School of Economics was started in 1895, he gave, in the rooms of the Society, a course of lectures dealing with the laws relating to the regulation of wages and employment; while his friendship with the late Mr. Chamberlain began in consequence of a course of lectures he gave during the South African War on "Imperial Organisation." He thought those two questions were really part of the same subject, and that it was not likely that the country would be able to escape from the present labour situation unless it proceeded to organise the resources of the British Empire. He recollected that in the last conversation he had with Mr. Chamberlain shortly before he died, he said there were two questions upon which England would have to concentrate if it wished to escape the great troubles he foresaw, viz., to deal sympathetically and in a large-minded way with the labour question, and, secondly, to organise the British Empire. Personally he was persuaded that the organisation of key industries lay at the basis of the settlement of the conditions of peace, and that unless a perfectly clear policy was defined with regard to those important products many of the arrangements which were now contemplated at Paris would be brought to nought by the impossibility of solving the economic issues which they involved.

The paper read was:—

KEY INDUSTRIES AND IMPERIAL RESOURCES.

By EDWARD J. DUVEEN.

Before dealing with my subject this afternoon, I should like to express my gratitude to the Council of the Royal Society of Arts for giving me the opportunity of placing before you some account of what are commonly referred to as British "Key" Industries. This important subject has received a great deal of prominence lately, and many writers and public speakers have attempted, with more or less success, to explain precisely what is meant by the term "key industries," and to define the place which those industries occupy in the economic structure of the nation and of the Empire. There is still room, however, for a concise description that will enable a wider public to envisage the true character of "key" or "pivotal" industries, and to understand their relation to national well-being.

It may be objected that as all industries are more or less interdependent, there is no special point in singling out any industries as "key" industries. In many cases it is of course difficult to lay down any hard or fast rule as to what is, or is not, a "key" industry; but for practicable purposes we can define the application of the term "to those industries which are in themselves comparatively small, but are, nevertheless, of vital importance, since upon their existence that of other and greater industries depends." This definition was used by Mr. H. J. Mackinder, M.P., in an able article which appeared in a booklet entitled "The Keys of Industry."

Many of our great industries—coal and steel, for example—are in a real sense "key" industries, since so many others are dependent on them. Thus we find that the threatened trouble in the coal trade and the grant of a possible large increase in wages to the miners has caused grave apprehension in many industries.

Coal has hitherto figured among the chief commodities exported from this country. Even before the war, competition was being seriously felt by British coalowners and shippers, and we may be sure that when competition starts again, British coal will have to fight very hard for its market against the production of other countries.

Competent authorities in many industries have averred that to grant the latest demand of the miners for 30 per cent. advance on present wages would place a very heavy burden upon the shoulders of those responsible for the reconstruction of industry.

Such advance would result in increasing the price of coal, which must affect the output cost, and have its effect on our ability to compete against foreign manufacturers in exports.

One point upon which emphasis should be laid is the effect of the miners' demand upon output. A shorter working day will probably reduce the amount of coal brought to bank, and even if this should not be so, it is to be feared that the increase in wages may have this effect. It has long been an axiom among those connected with the coal trade, particularly in County Durham, that an increase in wages is followed by a fall in output. There are many miners who are content to earn so much during the fortnight, and when they reach the amount, curtail work. A substantial rise would mean that they may earn more, but will probably convert part of the increase into more leisure. To keep up the output in these conditions would involve the employment of more men, and with a greatly increased wages bill, this would be a serious matter.

The handicap would weigh very heavily upon the textile industry, and place this country at a disadvantage in competition with other nations. At the same time, this would keep wool goods for home consumption at the high prices about which there has been so much complaint during the war. The consumption of coal in the wool textile factories is heavy, and forms an important item in the cost of production. At present the cost of this fuel ranges from 24*s*. 6*d*. to 30*s*. and even 35*s*. per ton. A particular class of coal for which a consumer paid 7*s*. 3*d*. per ton in 1903, cost in 1913 from 12*s*. to 13*s*., and at the present time is 25*s*. per ton. Wages in the textile wool trade are also on a very much higher level than in pre-war days, and employers are now faced with a demand for a reduction of working hours without reduction of wages. This forcing upwards of the cost of production is bound to be serious, not only for home consumers, but also in militating against the export trade, which in the past has provided employment for many thousands of operatives in the wool textile industries of the country.

The coal trade thus furnishes an instructive illustration of the interdependence of one

industry upon the other, and shows how a key industry influences other industries.

Many examples could be given of the economic loss to the nation, due to the neglect in developing industrial opportunities provided by the existence of raw materials within the Empire; the most striking are respectively the electrical, synthetic dyes, and optical industries. The distressing fact about these is that they owe their existence largely to British inventive genius, but they were allowed to pass from this country and to be developed in other countries, because economic conditions did not favour their further development in this country.

What our relative position was before the war in the electrical trade can be seen in the report of a Departmental Committee, where it is shown that the approximate annual value of the total products of electrical plant, mains and appliances in Germany was more than three times that of Great Britain, and the annual value of home-made electrical machinery used per 100 people was more than double that consumed in this country. In the production of machinery and appliances, and the employment of electrical power, we let other nations surpass us, though we were first to stake out claims in these fields. It is hardly an exaggeration to say that had we retained in our own hands the developments of these industries, the loss to the nation in blood and treasure during the past four and a half years would have been very much lighter than it has been.

Before and during the war people have commented upon the industrial backwardness of this country, which not so many decades ago stood absolutely foremost in the world in industrial production. In 1846, England produced approximately two-thirds of the world's coal, two-thirds of the world's iron and steel, two-thirds of the world's cotton goods, etc. It dominated the industrial world completely. Moreover, this country stood foremost in inventiveness, and fifty or sixty years ago all the most modern industries and processes were invented and exploited by Englishmen. Technically, England led the nations in the most scientific manufacturing industries. In some of the old-established industries, such as spinning and weaving of cotton and wool, shipbuilding, etc., that lead is still maintained. But in other industries, such as the manufacture of steel, chemicals, electrical plant and appliances, Germany and the United States, which were modest imitators of this country, have completely outpaced it. Among the modern productions for which this country was dependent on Germany and the United States before the war were automatic machinery and machine tools, boot and shoe-making machinery, diamond drills, electrical apparatus, fine and heavy chemical industries, electric lamps, photographic apparatus, porcelain, incandescent gas mantles, telephone apparatus, arc lamps, carbons, artificial silk, dentist's materials and implements, and many other of the most modern and most necessary wares and appliances.

The difference between old industry and modern industry lies in the application of science and organisation in production. These scientific processes and inventions have created key industries. Exactly as bacteriology is the key to modern medicine, and chemistry the key to modern steel manufacture, so there are countless scientific processes and inventions which have become indispensable for success in industry. Old industries require rejuvenating, require the touch of science to be brought up to date. Exactly as the old office requires the telephone and the typewriting machine, so the modern cotton industry requires the ring spindle and the automatic loom; and if science is neglected, industries become out of date and decline and decay.

England can regain her ancient predominant position in the world of commerce only by acquiring the indispensable key industries. Formerly the scientific industries were of little importance. Nowadays they are of very great importance. Before long they will be of supreme importance. We have felt the lack of the key industry very bitterly since 1914. The future will make key industries still more indispensable.

The question now arises: How can we secure possession of all the most necessary "key" industries? We must stimulate inventiveness to the utmost by technical education, by organising research, by giving the highest rewards to successful inventors. We must teach employers the necessity of keeping abreast of the times by making use of the most modern inventions and processes. We must teach the workers that it is necessary to employ all the most modern and most perfect methods, and not to obstruct them. But this does not suffice. We cannot secure that all the most necessary and valuable inventions are made by Englishmen. Therefore we must induce foreign inventors to bring their inventions to England, and must induce British manufacturers to

attract foreign inventions to England by appropriate State aid. In this way the Americans and the Germans have drawn from this country to their own lands many of our ablest inventors and of our most skilled workers, and have so transferred industrial supremacy from this country to theirs. Thus the industrial level has been steadily lowered in this country, while it was correspondingly advanced in the United States and in Germany.

Particularly necessary is the standardisation of industry and its organisation for extensive production. Industrial organisation may be described as the key to key industries. While English watchmakers continued making watches by hand in small numbers, in other countries the processes and parts were standardised and produced on a large scale. America introduced watch-making machinery in 1856. In that year one firm alone made 12,000 watches, in the next year it made 87,000, in the third year it made 225,000, and in 1915 its output was 5,000,000 watches.

This brings me now to a description of some of the "key" industries themselves. Time will not permit the survey of the whole field, but I hope that the following typical examples will illustrate my purpose. I propose, therefore, to deal only with the following, viz.:—

(1) Glass—chemical, etc., optical and heat resisting.

(2) Metals and minerals—tungsten, spelter, nickel, manganese.

(3) Magnetos, and

(4) Thoria and ceria.

In connection with chemical glass as a "key" industry, it might safely be claimed as a master "key," inasmuch as no experimental research work can be carried out without the aid of the necessary test tubes, evaporating flasks, thermometers, etc. Prior to the war our position was such that every manufacturing laboratory, as well as laboratories attached to our universities and hospitals, were compelled to go to Germany for the purpose of having their establishments equipped with the necessary glass. One of the chief dangers to British industry resulting from this dependence was the fact that in connection with any new scientific discovery where glass apparatus was required, we were compelled to send out ideas to Germany, where they were put into practical shape. Here is an example of what I mean: When Professor Sir James Dewar had discovered the double-jacketed vacuum flask, he made strenuous but vain attempts to have his idea worked in England, and was eventually driven to send the outlines of his idea to Germany. The result was that German manufacturers took advantage of British initiative, and immediately turned it to commercial use by bringing out the Thermos flask and placing that upon the market, long before the Englishman could gather the fruits of his invention. This is only one instance out of many, and my object in mentioning it is to show the danger of having to depend upon one's commercial competitors for a vital "key" of industry. On the other hand, we only realised the terrible danger of this practice at the outbreak of war, when supplies from enemy countries were suddenly cut off, and had it not been for the assistance given us by some French manufacturers, one hardly dares to imagine the nature of the terrible results that would have followed.

I suppose few people would believe that in the manufacture of explosives, where it is so necessary to have accurate thermometers to register the heat required, say, in stoving cordite, no such thermometers were made in this country. I was assured on visiting a works in this country, that before the war English firms were practically limited to repairing German thermometers and not manufacturing, the trade having passed entirely into German hands. The same thing applies in the case of our mobile laboratories, so necessary for military purposes. Here again, the whole of the glassware was of foreign manufacture. Even the tubes used in testing the poisoned water in wells had to be made in Germany. Sterilization plant, where sterilized water was all important in cases of operations, was all of German origin, and last, but not least, the instrument that I am able to show you here, which is used for testing cordite, was practically a German monopoly. You will see that this instrument consists of an outer bulb which is silvered within, an inner bulb silvered outside, and a vacuum, built on the principle of the Thermos flask, and based on the invention of Professor Sir James Dewar. The point I specially want to call your attention to is the horizontal tube which is inserted into the vertical tube at the right-angular junction of the two. This is made from sodaglass, and was imported from Germany. It was eighteen months after war began before we were able to make this glass in this country. My object in presenting these facts to you is to point out the immense danger to a great nation like ours in

being dependent upon foreign countries for its vital "keys" of industry.

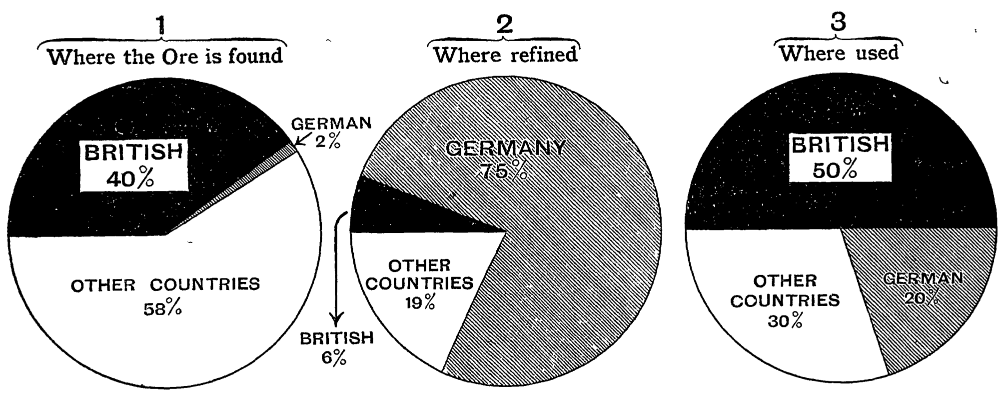
From chemical glass I will pass to optical glass, and would like to call your attention to our pre-war position; also to show by way of comparison what has been accomplished within the last four and a half years.

We all remember how in the early days of the war it was found impossible to supply the Army with the necessary binoculars and periscopes, and we are all still familiar with the posters issued in the name of Lady Roberts inviting those who possessed binoculars to hand them over to the Army. This appeal had to be made because we had neglected generally the manufacture of optical glass, with the result that at the critical moment there was not available sufficient skilled labour for the grinding of the lenses and prisms. I think I am well within the mark in stating that, in 1914, nearly the whole of the lenses and prisms used either for range-finders, gun-sights, periscopes, sextants, binoculars, telescopes, spectroscopes, theodolites, cameras, cinema lanterns, microscopes, etc., were either ground in Austria or Germany from Jena glass, or, in some few cases where the glass was ground here, the Jena glass was imported for the purpose. Perhaps this best illustrates our entire dependence upon Germany for this particular kind of glass. It is evident that however fine a battleship may be, however brave the tars that man it, the work it is designed to accomplish can only be carried out by having the necessary instruments that will give the range of the enemy ship, and also the sight for the gun. Some of you may be familiar with the small telescope which is generally fixed on the left-hand side of the field gun, and which is used to get the range of the object on which it is desired to drop the shell. Now it seems almost past understanding that we should have allowed an industry so vital for defensive purposes to become the monopoly of an enemy nation, when we remember that workpeople have to be trained to the art of grinding, an art which requires a great deal of skill and accuracy, not easily acquired.

You will appreciate how necessary it is for an industry like this, having once been firmly established, remaining permanently in British hands, so that our scientists—whether the astronomer tracing the path of a comet, or measuring the composition of celestial bodies by the aid of the spectroscope, or searching for bacilli with the microscope—shall never again be dependent upon foreign nations for instruments so vital in scientific research.

Turning from optical glass to heat-resisting glass, I have only to say in passing that whereas formerly we had to import from Germany the globes used for high-power electric lighting units, in which very high temperatures are generated, we have now established the industry in England, and a number of firms are engaged in the production of these bulbs.

TUNGSTEN FOR THE MANUFACTURE OF HIGH-SPEED TOOLS.



(This chart illustrates how the German metal "octopus" controlled the resources of the British Empire in 1914.)

Turning now to the consideration of metals as "key" industries, there is no doubt that tungsten holds a pre-eminent position. Glancing down the long vista of time, we see the stone age giving place to the age of bronze, and that in its turn, in the arts of war, to lead and steel —each of these may be said to be the "keys' of war in the periods to which they belonged—

and although the processes for the manufacture of steel tools have passed through many phases, and although the essential properties of tungsten steel have been well known for more than half a century, its application for high-speed tools is of quite modern date. It was not until the Paris Exhibition of 1900 that the modern era of tool steel began; then Taylor first exhibited to the astonished gaze of incredulous machinists the spectacle of a tool cutting so fast and deep that it delivered chips at a blue heat and in amazing quantities. It was, therefore, made possible by the use of these high-speed tools, cutting four times as much metal as the best of the older carbon steels, to produce results surpassing anything that could be performed by the use of other metals. It can, therefore, well be said that tungsten steel is the dominating factor in the production of machinery, whether for peace or war purposes, and to deprive a nation of tungsten is to cripple its military power in time of war and its industrial capacity in time of peace. One would have thought that with the recognition of this fact, and after the experiments of 1900, as a nation we should have set to work to secure for our own use this mineral property of the Empire. But this was not so. Germany properly appraised the situation, and with her usual thoroughness began to search for the world's tungsten supplies with the idea of obtaining a monopoly. The wolfram mines of Burma, which are undoubtedly among the richest in the world, came under the control of Germany, and even the ore mined in Cornwall was shipped across to Hamburg for refining, then re-sold to England. The position in 1914 was such that nearly all the tungsten powder used by the steel-makers of this country was imported from Germany, where they had established the industry for reducing the metal from the ore. However, at the outbreak of the war we at once realised how terrible was the situation, and, driven by necessity, we finally awoke to the importance of the situation, but not until we saw our supply of tools running out and possible disaster facing us. There is one consolation, however: when England realises the need of a thing she resolutely attempts to secure it, and at once, therefore, she took under control the Empire output, and although the latest figures are not available, at the beginning of 1917, out of the total of 19,000 metric tons of tungsten concentrates, which was then the world's output, England controlled and acquired 13,000 tons, or over two-thirds of the world's supply.

My object in presenting these facts to you is to impress the necessity of never again permitting the control of this vital "key" to pass out of British hands.

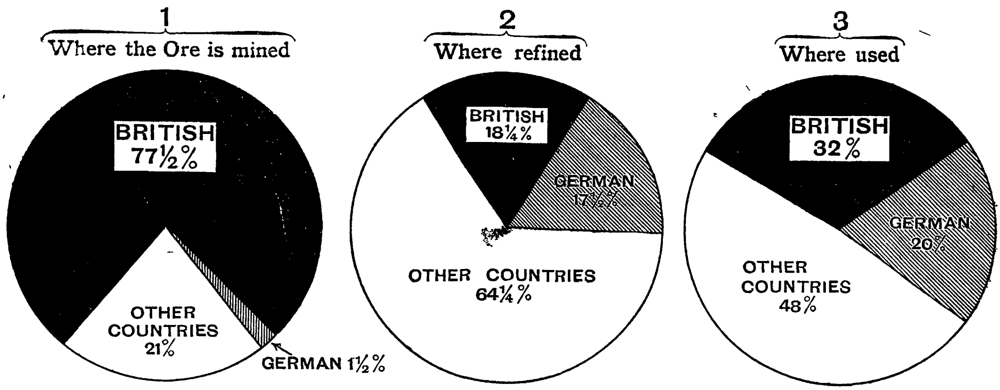
The position with regard to spelter was somewhat similar; although we possessed very large deposits of zinc concentrates, especially in Australia, we permitted a German concern—part of a world-wide German metal trust—to control the output of the British Empire. In 1910, Beer Sondheimer & Co., of Frankfort-on-Maine, contracted to take up the entire output of concentrates from the Broken Hill Mines for a term of years. The result was that at the outbreak of war the German firm suspended deliveries, and the mines ceased working for a time. The British Government was at this time in urgent need of spelter for munitions, yet nearly a year and a half elapsed before the mines were reopened and the German contract annulled. In fact, it was not until January, 1916, that the Government passed the Trading with the Enemy (Amendment) Act, which then empowered the Board of Trade to determine the contract with the enemy as injurious to the public interest. We permitted Germany to take possession of our lead, and send it back in the form of bullets to our men, as well as to hold up the supplies of spelter. I think we are very much indebted to the Commonwealth Government of Australia for having determined for the future that these British supplies shall be for British use only, and that no more zinc concentrates shall go to Germany. The result, therefore, is that some large refineries have been established both in England and in Australia to treat the ore. This means not only the establishment of a new industry, giving employment to engineers for the manufacture of large roasting ovens, but the safeguarding of one of the vital "keys" of industry against exploitation by foreigners.

Nickel, as you know, plays a very important part as an alloy with carbon steel for hardening purposes, and for use in armour plate, large and small guns, etc. Nickel ore is almost exclusively a British Empire product; more than 70 per cent. of the world's supply is mined within the Empire, and only $1\frac{1}{2}$ per cent. is found within the German Empire. In other words, two-thirds of the world's supply of nickel ore is found in Canada, the remaining one-third coming from New Caledonia, a French colony. Out of the world's total production of nickel ore in 1913, Canada's output was no less than 22,177 tons. British steel manufacturers

of necessity were large consumers of nickel, using more than 32 per cent. of the world's consumption of the metal, but if we turn to the amount of metal refined in this country we discover that only a little more than one-half of it was treated here. Thus, in regard to this metal also, we allowed the Germans not only to do the refining of British ore, but by so doing to dictate the market prices, as well as to hold a partial control over our industries.

NICKEL.

(The metal for National Defence.)



NOTE.—60 per cent. to 70 per cent. of all the nickel used in the United Kingdom is required for hardening steel.

In connection with manganese, the last of the chief "key" metals I have included on my list, here again we have very large supplies of the ore in India. In 1913 our imports from British India amounted to nearly 400,000 tons, as compared with 260,000 tons imported from all the rest of the world. Russia contributed to the latter amount over 240,000 tons. There are many commercial uses to which manganese is put, the most important of which is an alloy with carbon steel, producing a metal which is not only non-magnetic, but resists abrasion, and is so tough that, when cold, it may be bent almost double without fracture. I think I am well within the mark in saying that about 90 per cent. of the ore is devoted to the production of manganese steel. The remarkable properties of manganese steel, therefore, make it specially valuable in the manufacture of crushing-rollers, railway and tramway points, bullet-resisting helmets and gun-shields, shield plates for armoured cars, railway wheels, and in fact anywhere where excessive strain or wear and tear is required. Turning to other uses, manganese-dioxide plays a large part in the production of dry cells for electric bells, pocket lamps, etc. It is also used in the manufacture of pigments, chlorine and bromine, and in the manufacture of bleaching powder. In spite of its importance, Germany had acquired, before the war, the manganese monopoly, and even the output of our Indian mines was controlled by a number of German firms in the interests of the metal combine controlled from Frankfort, and there is no doubt that the capacity our enemies have shown to maintain their enormous output of steel for their guns and armaments during the war, must be due to the enormous stocks of this material which Germany had ready in anticipation of war: otherwise she could never have continued her vast output of steel through four years. I think I can safely say, in concluding my remarks concerning these metals, that they are worthy of being considered as vital "key" industries, and their importance well warrants the introduction of safeguards to prevent them passing under foreign control again.

MAGNETOS.

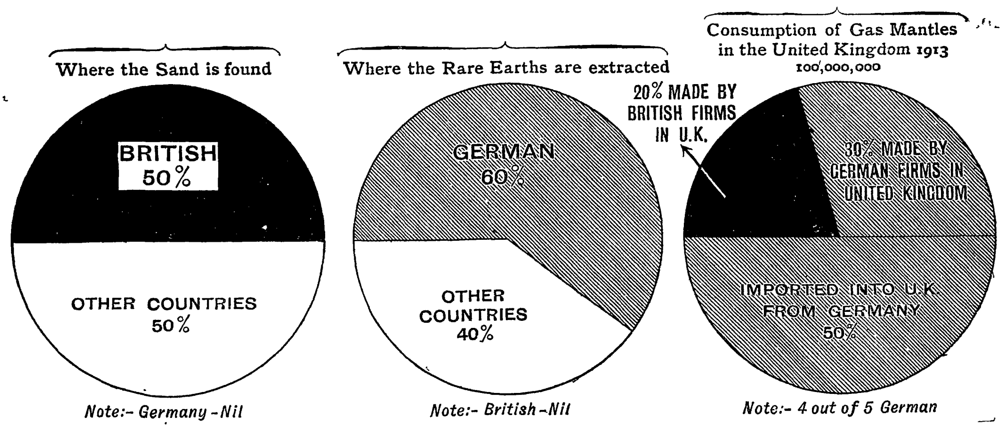
I now turn to the consideration of the magneto, which might well be considered as one of the chief "key" industries, especially when we realise the part played in modern locomotion by the internal-combustion engine, in connection with which the magneto is a vital part. Previous to the war, although some small attempts had been made to produce a magneto in this country, the position was such that the well-known "Bosch" magneto was universally accepted as the standard type by motor manufacturers and others. The result was that when war broke out, and the German supply was cut off, we found ourselves confronted with serious difficulties. Magnetos

were required for aeroplanes, tanks, and ambulance cars, all forms of motor transports, submarine chasers, and elsewhere. The question with which we were confronted was, how quickly could British manufacturers succeed in supplying the want? It was, however, soon realised that the making of the magneto was not such a simple matter as it seemed at first sight. In the first place, twenty separate raw materials were necessary for its production, amongst which I might mention tungsten, manganese, nickel, and zinc, the four "key" materials I have previously dealt with; but perhaps the greatest difficulty was in obtaining the necessary special materials used in the construction of the magneto. First of all came the production of steel for the permanent magnetos, of which we had permitted the Germans to acquire a virtual monopoly. The essential requirement of the magneto is its very high magnetic characteristic, coupled with great mechanical accuracy.

The difficulty, however, was overcome in this country, and we were at last able to turn out many thousands per week of good and efficient magnetos. Stabalite insulating material, used in considerable quantities, had not been manufactured in England, although Germany had been producing it since 1903, and had carefully guarded the secrets of its manufacture. Experiments had to be made, and eventually we succeeded in its production. Then we come to insulating paper and silk, used in connection with the armature windings. For some time our requirements were met by imports from America, but with the shortage of freights it became imperative to establish here the industry, and to satisfy our requirements. After a great deal of experimental work, success was achieved. Last, but not least, was the fourth chief ingredient, viz. enamelled copper wire, of about one four-thousandth of an inch in diameter. The production of this had to be very vastly improved from anything we had previously manufactured before it could be used for magneto purposes. The net result was that for the first year of war we had to rely very largely on taking magnetos from motor-cars and using them in our experimental aeroplane engines, with very serious consequences to the lives of our boys, who were so ready to try and defend us against German aircraft. Although we may look back with pride at what our manufacturers have done for us, we ought at least to draw from it a lesson that, for the future, it would be wisest to depend upon the energies of our people, and the resources of our Empire, rather than upon foreign countries. True, we are hoping that the demand for the magneto for purposes of war will not again arise for many generations, but there still remain the almost limitless possibilities of its application to peace work. In fact, it may be said that upon the magneto depends the new era of locomotion, particularly in its relation to aircraft.

MONAZITE SAND (1913),

from which thoria, ceria, didymium, and other rare earths are extracted and used for the manufacture of incandescent gas mantles, carbons for searchlights, etc.



Valuable and important in the arts of peace, these rare earths are of cardinal and vital importance to a nation at war.

MONAZITE.

The last of the "key" industries I have determined to deal with to-day is that of monazite sand, the study of which is a very fascinating subject. For many years German

chemists must have carried out a vast amount of experimental research work to have discovered the wonderful hidden properties of this sand, which is of yellow colour, and separated from the Travancore sand of India. I believe I am right in stating that the Maharaja of Travancore originally granted a concession to a British company to work the deposits, but, later on, German influence was brought to bear upon the company, and eventually succeeded in obtaining control. The result was that practically the entire output of the monazite sand of India was, before the war, shipped to Germany. From this sand, thoria, ceria, didymium and other rare earths are extracted for use in the manufacture of incandescent gas mantles, carbons for searchlights, and other forms of electric lighting purposes. Besides these uses, there are many others. For instance, in the case of ceria salts, they are used as mordant in leather dyeing; cerium oxide is used for colouring glass, and for medical purposes; cerium mercury alloys are spontaneously inflammable in air; cerium oxalate is used for medical and surgical purposes, whilst cerium is used in the production of automatic lighters, having peculiar sparking properties. On the other hand, didymium nitrate is used in branding the name on gas mantles, as well as in the manufacture of marking inks and dyes. There is also another of the rare earths which I should mention, viz. lanthanum, which I am given to understand is largely used for medical purposes. However, from a commercial point of view it may be said that thorium and cerium are the two chief earths, as they play the principal part, as I have just indicated, in the manufacture of incandescent gas mantles and carbons. For instance, the annual consumption of gas mantles in the United Kingdom in 1913, was approximately 100,000,000. Now, about 20 per cent. of these were produced by British firms in the United Kingdom, but the remaining 80 per cent. were either imported from Germany and Austria or manufactured by German firms in this country. This almost complete monopoly was entirely due to allowing an enemy nation to exploit our Empire raw material. The same applied in the case of carbons. Carbons for searchlights, kinematographs, and electric flame arc lamps were produced in Germany for the same reason as they were able to produce the gas mantles, and had it not been for the determined effort on the part of one company to try and establish a British carbon industry, which they did at serious financial loss, we should have found ourselves, when war was declared, unable to secure carbons for the searchlights used on our battleships. Even then they did not possess the high illuminating properties that they have to-day, which, as you will understand, was entirely due to the fact that the earths to which I have referred to were not extracted in this country and under our control. Happily all this is changed.

In the course of this paper I have attempted to emphasise the importance of obtaining essential "key" industries for our nation; what remains is for the State to ensure that the new industries shall be allowed to establish themselves upon a sufficiently strong foundation to enable them to face all foreign competition.

DISCUSSION.

The Chairman (Mr. W. S. A. Hewins), in opening the discussion, said the author had shown quite clearly what was involved in certain aspects of the war, as it had to be conducted on its economic side. He (the Chairman) did not think that the great mass of the people even now realised in the least how, before 1914, Germany had almost destroyed the British Empire. Just a little more patience on the part of that Power and a little more lulling to sleep of the English people, and the conduct of the war by this country and by France would have become absolutely impossible. The tragedy of the situation as revealed by Mr. Duveen was that the resources upon which the German power was built up were in the British Empire. During the war many investigations had been held upon that subject. He himself had presided over various committees which had been engaged on the work, and the impression left upon his mind was that this country had not at present absolute or complete control over many commodities; but its control over the vast proportion of the products referred to by the author was so great, that if the British Empire used the intelligence which it possessed no one could touch it. If, by the continuance of our policy of neglect, we had been beaten in the war, and the great civilisation which England represented had been destroyed, the blame would have been not upon the younger generation of the country, but upon the people of the older generation who, in spite of warnings, deliberately persisted in the policy of neglecting the great heritage with which God had endowed us. But he was not sure that the conditions which had existed in the past had changed. Great constructive work had been built upon the foundations of what had been prepared at the Imperial War Conference; but he seemed to see, in the spirit that had followed escape from the appalling danger with which the country had been threatened, signs of the country sliding back into the old grooves. If this country was to obtain real security,

he had no hesitation in saying that it was impossible to neglect the working out of the necessary measures for a single day. Instead of falling back into a state of inertness, all the knowledge which had been accumulated during the war ought to be used persistently to build up measures of control and organisation which would make the deplorable state of things disclosed by the paper impossible in the future. It was not so much a question of profit, but of very much higher considerations, namely, preserving the great traditions which had been handed down to us, and solving the great questions which were now vexing statesmen all over the world. Personally he would not advocate that strong measures should be taken merely for the sake of making the country richer, important as that was; but in view of the great death roll of our young heroes, the sorrow that had been inflicted, the irreparable sacrifices that had been made, the universal grief, and many other considerations, this country deserved any fate that was in store for it if it hesitated for a moment in building upon the foundations of what had been done in the war, with the object of seeing that such things could never occur again. He was not in any way pressing for the impossible; he knew such things were possible, because the country had the men, the resources, the intelligence, and the statesmanship which could put beyond all risk of recurring the appalling situation which had been set forth in the paper.

[The chair was then vacated by Mr. Hewins and occupied for the remainder of the meeting by Mr. T. J. Bennett, C.I.E., M.P.]

Mr. Percy Hurd, M.P., said that while the story the author had told was a very humiliating one for the present generation of Britons, it was also an inspiring one because, although neglect, and the fearful penalty that had been paid for it, was admitted, it was quite obvious that the adaptability and the genius of the race had been brought out to overcome the many difficulties with which the Empire was faced, with the tremendous results over which the country had recently been rejoicing. The remarks made by Mr. Hewins in regard to the attitude of the Government towards the vital problem under discussion might have a depressing effect. It was true the problem was a very difficult one. The author had followed Mr. H. J. Mackinder, M.P., in trying to define what a key industry was, but it was a very unsatisfying definition. For instance, the war (through the submarine) had proved that agriculture was a key industry indispensable to the nation's existence. If an attempt was made to schedule the key industries of the country, it would be found that they covered practically the whole range of British production; and Ministers would not be able to find any foothold for dealing with the question unless they dealt with it as a problem affecting the whole of British industry. It was impossible to treat industrial policy in watertight compartments, as many Ministers were trying to do; it must be treated as a whole, not only because of the unemployment problem, but also from the point of view of the international aspects of the economic question. In view of the title of the paper, he thought the author would have said something in regard to the method by which Imperial resources were to be conserved. Under the present methods of import restrictions, import licences were refused; for instance, for many Canadian goods which were urgently required in this country, liberty to import by licence was granted on a war basis only. Naturally the Canadian Ministers were furious, and he hoped some method would be evolved by means of which British Ministers would be made to face the problem as a whole, to recognise that the Empire was one family, and to see to it that our partners in the Empire were treated in a proper manner.

Sir Joseph Lawrence, Bt., said that in regard to the question of the definition of key industries he felt very much in the same position as the great Edmund Burke who, speaking of a cognate subject, said: "Few man can tell the exact point at which twilight becomes darkness or the dawn becomes morning, but all men can tell the difference between daylight and darkness." In defining a key industry, he thought it would be necessary to fall back on the broad common sense of the people of the country as to whether an industry was an essential industry bringing employment to the people, producing revenue for the country, and generally conducing to the upholding of the stability of the industrial position. It was impossible to make minute definitions. The author, in referring to the foolish manner in which this country had been dependent in the past on other countries, had alluded to the subject in a way which conveyed the impression that the people of England had been somewhat asleep, and not alive to their own interests. That might be partly true, but economic and legislative causes had also played their part. For instance, in 1881 the late Mr. Ivan Levinstein and himself called attention to the manner in which the Germans were abusing the patent laws of this country in regard to the aniline dye industry. The original conditions upon which, from Elizabethan times, a patent was granted to any man were that it brought a new industry into the realm, and gave employment to His Majesty's subjects, those conditions being set forth on the front page of every patent grant that was made; but unfortunately those two essential conditions were allowed to fall into desuetude, and foreigners were allowed to take out patent monopolies in this country, and were not called upon to give the State any *quid pro quo*. After many years had been spent in endeavouring to obtain an alteration in the law of this country, Mr. Lloyd George eventually, in 1902, passed the Act whereby any foreigner taking out a patent in

this country and not working it should give what was called a compulsory licence to work it, which was half the loaf; and eventually in 1906 Mr. Lloyd George brought in his Bill which rendered it obligatory upon people taking out patents in this country to erect works and effectually work the patents. One of the first results was that the German chemical industry, seeing that it would be useless any more to exploit England under the old *régime*, bought a big site at Ellesmere Port and put up enormous works for making German dyes, which were subsequently taken over, when the war broke out, by a British concern, which was now supplying the textile manufacturers of this country with dyes, not only equal to the old German dyes, but including new and important colours of superior fastness. It was, therefore, evident that legislative and economic causes played a greater part in the question, rather than the shortsightedness and the lack of genius of the British people. The people of this country were not so sleepy as was sometimes thought; they were not wanting in native genius and in chemical and mechanical skill. It was necessary, however, to awaken in the minds of the people of the country a realisation of the dangers to which British industry had been subjected in the past by the competition of other nations, and anyone who, like the author, was endeavouring to do so, was doing a great work for the country.

Mr. Ed. C. de Segundo said that a well-known writer had stated last year that "everyone could see there could not be much wrong with the trade policy of a country which had shown such amazing financial strength and commercial vitality during a period of cosmic upheaval," such as the country was then going through, meaning that the free trade policy of the country was the cause of its amazing financial strength and commercial vitality. The argument did not necessarily apply. The hypothesis that we are financially strong in spite of our free trade policy and not because of it, would be an exceedingly difficult one to refute, particularly in view of the amazing financial strength developed in Germany since 1879 (when Bismarck introduced protection), and the even more amazing financial strength exhibited by the United States, which had always been a protectionist country. Protection, as understood by a very large number of people, was the art of making it difficult to bring certain things into this country, in order that it might be made easy for those who manufactured those articles in this country to produce them at no matter what cost, and force those who needed them to pay no matter what price. Clearly this was "the very dementia of stupidity." But there was such a thing as "sane protection." A patent grant was a form of protection, and afforded time for the development of an invention. Similarly, an industry beginning its career should be "protected" until it was strong enough to stand on its own feet and meet competition in the international market, and—*a fortiori*—every industry, without which the country would fall an easy victim to enemy action in time of war, should, at all costs, be maintained and fostered by State action. He would not attempt a general definition of a key industry, but coal-mining, for instance, was assuredly not only a key industry, but a vital industry, and he thought the production and use of coal should be governed by considerations affecting our national welfare rather than individual benefit. Scientific effort and research, had, of recent years, greatly increased the yield of gas and of other products of national importance from the carbonisation of coal. If gas were burned in modern gas fires instead of coal in open grates, the consumption of coal for domestic purposes could be reduced from 35 million tons per annum to 10 million tons. The cotton-spinning industry should surely rank as a key industry. Cotton goods, according to Professor John A. Todd, represent from one-fifth to one-fourth of the total value of our exports, and yet the Lancashire spinning industry has for years been dependent for 80 per cent. of its raw material upon the United States. This type of cotton could be grown within the British Empire just as well as in America, and within the last three or four years steps had been taken to stimulate the cultivation of the American type of cotton in various parts of the Empire, notably in India. The American type of cotton possessed the peculiarity that, in addition to the long staple fibres which grew upon the seed, and which were removed for purposes of spinning, there was an undergrowth of short cotton fibres which escaped the action of the gin or of any subsequent saw-linting operations. Until recently these short cotton fibres had been wasted, but he was in a position to state that they were now recoverable in a merchantable form, and had already been extensively used for the manufacture of explosives and paper. This material was also suitable for the manufacture of artificial silk, cellulose acetate, and other cellulose derivatives. Whether it should be termed a key industry he did not pretend to say, but it was a new industry which was receiving whole-hearted support. He agreed with Mr. Hewins that the nation did not seem as yet to have learnt one of the most vitally important lessons of the war, and he hoped the author would continue his good work of endeavouring to awaken the nation to the necessity of efficiency in the development and protection of its industries and the consolidation of the resources of the Empire, to the end that this country, and the Empire as a whole, should become independent of raw materials and manufactured articles which had come to be drawn almost entirely from enemy countries.

Sir Edward Davson, in proposing a vote of thanks to the author for his excellent paper, said Mr. Duveen was doing a great service by the way he was pressing the subject upon the

attention of the public. If the recent exhibition of raw products which was formed by Mr. Duveen could have been taken about the country, it would have brought home to the people the vast importance of the subject. Grave warnings had been uttered by most of the speakers who had joined in the discussion, and he hoped the publicity the subject was now receiving would be the means of making the Government realise the importance of the question and doing something to bring about a better state of affairs. Personally he trusted to the common sense of the country. The Empire had won the war, and he hoped, by means of common sense, they would be able to win the peace.

The Chairman seconded the motion, which was carried unanimously, and Mr. Duveen having briefly acknowledged the compliment, the meeting terminated.

Mr. Duveen writes:—I should like to thank Professor Hewins and the other speakers for their remarks upon my paper. The absence of any note of criticism relieves me of the task of replying at any length to the observations that were made by the speakers, and these few remarks will be confined, therefore, to help to elucidate one or two points which naturally arise from the paper. Mr. Percy Hurd, M.P., very properly draws attention to the absence from the paper of reference to specific methods for conserving the resources of the Empire. I purposely abstained from dealing with this aspect of my subject, tempting though it may be, in order to avoid raising contentious issues, and thus diverting attention away from my main object, which is to indicate the character and extent of Imperial resources, and to urge the necessity of husbanding them in the economic interests of the various peoples within the Empire. All I need say here is that the immediate removal of vexatious regulations which restrict the free development of trade between Great Britain and the other countries within the Empire is essential, and if Mr. Hurd, from his place in the House of Commons, can help to bring about this important reform he will have achieved a further step towards the realisation of the great ideal of a united Empire. Any attempt to define a "key" industry is bound to raise some objection, but I think that on the whole the definition given in my paper conveys a fair and reasonable meaning of what a "key" industry is. The various industries are now so closely related and interdependent, that practically every one is, in a measure, a "key" to the others. But those industries which I have dealt with are, in a far larger degree, pivotal to industries of greater magnitude; hence they merit special consideration from the people of this country. I am in entire agreement with the views expressed by Sir Joseph Lawrence, and am very pleased that he has so effectively disposed of the current fallacy that Englishmen are somewhat lacking in inventive genius. The pre-war economic policy of this country, which so greatly restricted our markets, and consequently our manufacturing capacity, made it difficult to provide sufficient scope for the application of the results of scientific research, and many British ideas were commercially developed abroad because unrestricted foreign competition hindered the creation of new industries here. It is gratifying to think that the first effective measure of protection for British industry was introduced by the present Prime Minister in 1906, when the new Patents Act was placed upon the Statute Book. Mr. Lloyd George has now the opportunity of extending the measure of protection which the war has shown to be so necessary.

CORRESPONDENCE.

THE WAGE PROBLEM IN INDUSTRY.

I wish to thank Mr. W. L. Hichens for his very valuable paper on "The Wage Problem in Industry."

I am of opinion that if all British workers in these Isles were instructed more freely, as the author of the paper evidently is trying to do, in the subject of Political and Domestic Economy, and that they are all to work together against an outside foe, real or imaginary, for their internal and mutual benefit, all questions of capital and labour would disappear, and we should be at rest and peaceful.

D. R. Broadbent.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

March 12.—Walter Leonard Lorkin, A.M.I.E.E., "Electric Welding and its Applications." Sir Robert A. Hadfield, Bt., D.Sc., F.R.S., will preside.

March 19.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity." The Right Hon. Lord Moulton, G.B.E., K.C.B., F.R.S., will preside.

March 26.—Arnold Hartley Gibson, D.Sc., M.I.Mech.E., Professor of Engineering, University College, Dundee, "British Engineering and Hydro-Electric Development. (The Training of Engineers.)"

April 2.—W. Norman Boase, "The Cultivation and Preparation of Flax, and the Linen Industry." The Right Hon. Lord Colwyn will preside.

April 9.—Leonard Erskine Hill, M.B., F.R.S., "Housing and Infant Mortality."

April 30.—Sir Herbert Jackson, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems."

MAY 7.—JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 14.—H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

MARCH 13.—D. T. CHADWICK, I.C.S., Indian Trade Commissioner, "The Report of the Indian Industrial Commission." The Right Hon. LORD INCHCAPE, G.C.M.G., K.C.S.I., K.C.I.E., will preside.

APRIL 3.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m. :—

MAY 27.—SIR EDWARD DAVSON, President of the Associated Chamber of Commerce, British West Indies, "Problems of the West Indies."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." Three Lectures.

Syllabus.

LECTURE I.—MARCH 10.—The coal question in the light of post-war economic conditions and requirements—Future lines of investigation and research.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 10...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor W. A. Bone, "Coal and its Conservation." (Lecture I.)

Royal Institution, Albemarle-street, W., 3 p.m. Captain G. P. Thomson, "The Dynamics of Flying."

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. A. S. E. Ackermann, "Experiments with Clay in its relation to Piles."

Geographical Society, Burlington-gardens, W., 8 p.m. Major J. B. Noel, "The Eastern Approaches to Mount Everest."

TUESDAY, MARCH 11...Industrial Reconstruction Council, 2, Tudor-street, E.C., 6 p.m. Captain J. O'Grady, "Labour Conditions in relation to future Industrial Property."

Royal Institution, Albemarle-street, W., 3 p.m. Professor H. M. Lefroy, "Insect Problems." (Lecture IV.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Messrs. J. Caldwell and H. B. Sayers, "Electric Welding Developments in Great Britain and the United States of America." 2. Mr. W. S. Abell, "Experiments on the Application of Electric Welding to large Structures." 3. Mr. J. R. Smith, "The Application of Electric Welding in Ship Construction and Repairs."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 7 p.m. Mr. W. A. D. Englefield, "The Early History of the Painting Craft in London."

Colonial Institute, Central Hall, Westminster, S.W., 8 p.m. Mr. C. Roberts, "The Proposed Reforms in India"

Anthropological Institute and Prehistoric Society of East Anglia (Joint Meetings), at the Geological Society, Burlington House, W., 3 p.m. 1. Mr. R. A. Smith (Presidential Address), "Foreign Relations in the Neolithic Period." 2. Mr. L. Abbott, "Exhibition of Flints from the Cromer Forest-bed and the Admiralty site, Whitehall."

5.15 p.m. 1. Mr. S. H. Warren, "The dating of Surface Flint Implements and the Evidence of the Submerged Peat Surfaces." 2. M. Leon Coutil, "Note on an Allée Couverte discovered in the course of making trenches for the defence of Paris."

WEDNESDAY, MARCH 12...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. W. L. Lorkin, "Electric Welding and its Applications."

Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. H. Levy, "From Model to Full Scale in Aeronautics."

Geological Society, Burlington House, W., 5.30 p.m.

Labour Co-Partnership Association, Kingsway Hall, Kingsway, W.C., 4.30 p.m. Paper on "A Ruskin Business."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor Sir Thomas Oliver, "After-War Reconstruction—Social and Medical."

THURSDAY, MARCH 13...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. D. T. Chadwick, "The Report of the Indian Industrial Commission."

Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, W., 8.30 p.m.

Britain and India, 7, Southampton-street, Holborn, W.C., 3 p.m. Mrs. A. Haig, "Indian Music."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Aitken, "Whistler and Sargeant." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. C. J. Grist, "Bygone Surrey."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. G. L. Addenbrooke, "Dielectrics in Electric Fields."

Historical Society, 22, Russell-square, W.C., 5 p.m. Mr. G. Davies, "The Attitude of the Whigs towards the Peninsular War (1808-1814)."

FRIDAY, MARCH 14...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor A. Keith, "The Organ of Hearing from a New Point of View."

Malacological Society, at the Linnean Society, Burlington House, W., 7 p.m. 1. Messrs. A. S. Kennard and B. B. Woodward, "On *Helix revelata*, Britt. auctt. (*non* Férussac, *nec* Michaud) and the validity of Bellamy's name of *Helix subvirescens* in lieu of it for the British Mollusc." 2. Mr. A. Reynell, "Forbes' Notes on Loven's 'Index.'" 3. Sapper H. Watson, "Notes on *Hygromia limbata* (Drap.)."

SATURDAY, MARCH 15...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Spectrum Analysis and its Application to Atomic Structure." (Lecture II.)

Chromatics, International College of, Caxton Hall, Westminster, S.W., 3 p.m. "Colour Causerie."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—March 7, 1919.

No. 3460. MARCH 14, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Royal Society of Arts

CANTOR LECTURES.

A full list of the Cantor Lectures which have been reprinted from the **Journal** and published separately may be obtained on application to

THE SECRETARY, John Street, Adelphi, London, W.C.

HOWARD AND OTHER LECTURES.

Heavy Oil Engines. Four Lectures. By Captain H. RIALL SANKEY, R.E., M.Inst.C.E. (1912.) Price 1*s*.

Aeronautics. Three Lectures. By Prof. J. E. PETAVEL, D.Sc., F.R.S. (1913.) Price 1*s*.

Surface Combustion. Three Lectures. By Prof. WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S. (1914.) Price 1*s*.

Motor Fuel. Three Lectures. By Prof. VIVIAN B. LEWES, F.I.C., F.C.S. (1915.) Price 1*s*.

Coal and its Economic Utilisation. Three Lectures. By Prof. JOHN S. S. BRAME. (1917.) Price 1*s*.

The Shortage of the Supply of Non-Phosphoric Iron Ore. Two Lectures. By Prof. WILLIAM GEORGE FEARNSIDES, M.A., F.G.S., M.Inst.M.E. (1917.) Price 1*s*.

Journal of the Royal Society of Arts.

No. 3,460. VOL. LXVII.

FRIDAY, MARCH 14, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 17th, at 4.30 p.m. (Cantor Lecture.) WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." (Lecture II.)

WEDNESDAY, MARCH 19th, at 4.30 p.m. (Ordinary Meeting.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity." The Right Hon. LORD MOULTON, G.B.E., K.C.B., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On Monday afternoon, March 10th, PROFESSOR W. A. BONE, F.R.S., delivered the first lecture of his course on "Coal and its Conservation."

The lectures will be published in the *Journal* during the summer recess.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 12th, 1919; SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Critchley, Captain James Sidney, R.A.S.C., M.I.Mech.E., M.I.A.E., Cleveland, Ohio, U.S.A.
Foster, Captain Fermian Le Neve, Pinner.
Harding, Charles Victor Malim, Toronto, Canada.
Henderson, Captain Thomas, M.C., R.A.F., Tynemouth.
Monro, George, Jun., London.
Simpson, Arthur Tate, A.M.I.A.E., Hull.
Staite, Edward Henry, A.M.I.A.E., Bristol.
Summers, Captain Lynar Frederick, R.A.S.C., London.
Woolley, A. Herbert, Nottingham.

The following candidates were balloted for and duly elected Fellows of the Society:—

McLean, William Hannah, M.Inst.C.E., Alexandria, Egypt.
Merriam, C. P., London.
Roberts, Walter, Stockport.
Scrivener, Frederic Adam, London.
Singh, His Highness Raja Sir Bhuri, K.C.S.I., K.C.I.E., Punjab, India.
Tetsall, Ernest Peter, Ipswich.

A paper on "Electric Welding and its Applications" was read by Mr. WALTER LEONARD LORKIN, A.M.I.E.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

Thursday afternoon, March 13th; SIR CHARLES C. McLEOD in the chair. A paper on "The Report of the Indian Industrial Commission" was read by Mr. D. T. CHADWICK, I.C.S., Indian Trade Commissioner.

The paper and discussion will be published in a subsequent number of the *Journal*.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1919 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 29th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce."

The list of those who have received the medal since its institution in 1864 was printed in the last number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

TWELFTH ORDINARY MEETING.

WEDNESDAY, MARCH 5th, 1919; PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute, in the chair.

The paper read was—

THE RUBBER INDUSTRY—PAST AND PRESENT.

B. D. PORRITT, M.Sc., F.I.C.,
Chief Chemist to the North British Rubber Company, Ltd.

It is difficult in these times to realise that a hundred years ago scarcely any noteworthy practical application had been found for rubber, and that it was not until about 1844 that all the initial fundamental problems incidental to its manufacture into serviceable articles were finally surmounted.

As this material has been known to Europe for over four hundred years, it will perhaps be of interest to follow its development from being merely a curio, imported from foreign lands, to its reaching the position of an essential raw material for the manufacture of innumerable articles almost indispensable for modern everyday existence. The first European to become acquainted with rubber appears to have been Christopher Columbus, since the historian, Antonio de Herrera,* states that on the explorer's second voyage to the New World in 1493–1496, the latter saw the inhabitants of Haiti playing with balls which he learned were prepared from the gum of a tree. The unusual material of which these balls were made was also noted in 1536 by Gonzalo d'Oviedo y Valdas, and by other early writers. The first record of rubber being employed for utilitarian purposes appears in a work by Jean de Torquemada in 1615, it being therein stated that the Spanish conquerors in Mexico used the material for painting their linen coats to protect themselves against the rain. This writer further mentions that, while water did not penetrate, sunlight produced a detrimental effect on these garments.

The actual introduction of useful rubber articles to Europe appears to have followed the colonisation of Brazil, in the early part of the sixteenth century, by the Portuguese who, as they later began to extend their settlements from the coast into the interior, and up the Amazon Valley, found that the natives were skilled in making, not only balls, but useful articles, such as shoes, ponchos, and watertight bags out of the sap of a tree which flourished in the country. Consequently, in the first half of the eighteenth century, considerable quantities of such rubber articles began to reach Europe through Lisbon, and we find in 1759* the Government of Para sending a suit of rubber clothes as a present to the King of Portugal, who four years previously had sent several pairs of his boots to Brazil to be waterproofed with rubber.

In 1736 the French Academy sent out a scientific expedition to Peru to settle certain geographical questions, and one of the members, De la Condamine, sent home samples of "Caoutchouc," together with a description of the "Hhévé" tree from which the natives obtained it.† He further ascertained the methods by which the natives of the Amazon Valley made their waterproof garments, shoes, bottles, syringes, etc., by coating fabrics and clay moulds with latex, and drying each coat as applied over a fire. After Condamine's return to France the inquiry was continued by Fresneau, a French engineer, stationed at Cayenne in French Guiana. One remark in his report is specially noteworthy.‡ He concludes a description of the native methods of tapping the tree, and thus securing the milk by saying, "Mais toutes ces choses ne peuvent s'exécuter que sur les lieux où croissent ces arbres, car ces sucs perdent bientôt leur fluidité." §

In these early days, therefore, the manufacture of rubber articles had perforce to be restricted to the primitive methods employed by the natives of South and Central America, and before its use could become widespread means evidently had to be found to restore to the coagulated rubber that fluidity which it possessed in the form of latex, or other processes devised to apply it to fabric or shape it into serviceable articles.

The times were unsettled, European strife and defective communications by land and sea retarded the progress of arts, learning, and

* "The General History of the Vast Continent and Islands of America," by Antonio de Herrera. Translated by Captain John Stevens, 1725. Vol. I. p. 166.

* "Rubber." Edith A. Browne, 1912, p. 14.

† This report, sent to the Académie des Sciences in 1736 by Condamine and Bouguer, was never printed. See *Mémoires de l'Académie Royale des Sciences*, 1751, p. 319, for an abstract, and 1745, p. 391, for an account of Condamine's journey from Quito to Para down the Amazon.

‡ *Mémoires de l'Académie Royale des Sciences*, 1751, p. 323, *et seq.*

§ Incidentally, it is interesting to note that the manufacture of rubber articles from the latex is still carried on by the native tribes of the Amazon Valley. Pearson, "The Rubber Country of the Amazon," p. 131.

invention, and many years had still to pass before conditions were favourable for a successful solution of the problem.

The potential value of rubber did not, however, escape the attention of the inventive minds of the eighteenth century.

Probably at Condamine's instigation the problem of dissolving rubber was taken up by two French investigators, Macquer, a chemist, and Hérissant, a physician. The latter proposed the use of turpentine for the purpose of preparing solutions, while Macquer recommended purified ether instead, as he found that when rubber was dissolved in this way, and coated on wax moulds, the film left after the evaporation of the solvent possessed all the characteristics of the original material free from the adhesiveness which resulted from the employment of a turpentine solution.*

In 1791 it is stated that an Italian engineer, Fabroni, suggested the suitability of petroleum as a rubber solvent,† but though this substance had been known from the earliest times, it did not come into general use for illuminating and other purposes until about 1860, when the exploitation of the American oilfields began.‡

No technical development, however, resulted from these observations, although various patents were issued in this country § for water and air proofing solutions prepared from turpentine and rubber. In order, however, to explain the slow progress made in solving what would appear in the present day a very simple problem, we must go back four generations and picture the scientific and technical facilities of the time.

In the period immediately preceding 1800, the work of Black, Priestley, Cavendish, and Lavoisier, had just disposed of the phlogiston theory of combustion, and had paved the way for the subsequent work of Dalton and other investigators, which resulted in the enunciation and establishment of the atomic theory, and rendered possible the rapid development of chemical knowledge, which took place in the first half of the nineteenth century.

* Macquer, *Mémoires de l'Académie Royale des Sciences*, 1768, p. 209, *et seq.*

† Dubosc, "Le Caoutchouc et la Gutta Percha," 1912, p. 6776.

‡ Boverton Redwood, Cantor Lecture, Royal Society of Arts, 1886. According to information supplied by Messrs. James Miller, Son & Co., Glasgow, and James Sclater, Esq., Edinburgh, Scottish rubber manufacturers did not begin to employ shale naphtha until about 1875.

§ Samuel Peal, English Patent No. 1801, May 2nd, 1791; Henry Johnson, English Patent No. 2188, July 26th, 1797; John Clark, English Patent No. 3718, July 14th, 1813.

Organic chemistry was at this period still in its infancy, and the solvents available were limited to simple substances such as vegetable oils, impure turpentine, vinegar, ether and alcohol. In this connection, it is perhaps of interest to recall that it was not until 1825 that Faraday isolated benzene from oil gas, and that the composition of coal tar naphtha was practically unknown until about 1845, when Hofmann and his pupil, Mansfield, began their investigations.* We find even as late as 1833 a proposal to employ the products of the destructive distillation of rubber as a solvent for rubber itself.†

In those days of tallow dips and colza oil lamps, the preparation of a solution of rubber suitable for coating fabrics was for the time being impracticable. Meanwhile, the chief employment of rubber was for the purpose of erasing pencil marks—a use suggested by Priestley in 1770, in the introduction to his book on "Perspective," and for the construction of surgical tubing to form which strips of crude rubber, softened with turpentine, were laboriously cemented together on a rod and wrapped with cord until dry.

The former use accounts for the adoption of the name "India Rubber" or "Rubber" in English, in place of the original native designation of "caoutchouc," which is still generally employed elsewhere in Europe.

We now come to a date which marks the beginning of a new era in industrial and pure organic chemistry, namely, that of the first practical use of coal gas in England for the purpose of illumination in 1798, at Soho near Birmingham. The practice rapidly extended, and in 1815 it would appear that more than 4,000 Argand gas lamps were employed for street lighting in London alone.‡ In these early days there was probably little demand for the tarry by-products resulting from the destructive distillation of coal in the primitive gasworks, but within a few years the work of Hancock and Macintosh found a useful application for some of the products, and sufficed to place the rubber proofing industry on a firm technical basis.

About the year 1819 Thomas Hancock began the long series of investigations which were destined to make his name famous as the founder of the rubber industry.§ His first experiments

* Memorial Lectures, Chemical Society. Vol. I. p. 598.

† W. H. Barnard, English Patent No. 6466/1833.

‡ Thorpe's "Dictionary of Applied Chemistry," 1906, Vol. II. p. 177.

§ Thomas Hancock, "The Origin and Progress of the India Rubber Manufacture." London. 1857.

were directed to preparing a solution of rubber in turpentine, for the purpose of waterproofing fabrics. As might be expected from the employment of the crude solvent then available, the resultant hand-coated materials were both sticky and malodorous,* and Hancock soon turned his attention to the production of elastic threads for the wrists of gloves and similar purposes,† by cutting strips from the "bottles," or lumps of crude Para, which were imported from Brazil for making into "erasers," which by this time were already firmly established in popular favour.

It was naturally not long before he was confronted by a large accumulation of small useless scraps of rubber in his works. Hancock straightway faced the problem.‡ He had already noticed that the warm freshly-cut sheets from the crude material would unite under pressure, and he judged that if he chopped his waste cuttings sufficiently finely, and pressed them together, he should obtain a similar result. This cutting proved to be a difficult operation, so it occurred to him that the same effect might better be secured by tearing the rubber in a cylinder between stationary and revolving spikes.

To his surprise, instead of a mass of shreds of rubber appearing when he opened his machine, he found that the scraps had become welded into a solid homogeneous roll, which could be shaped into blocks by pressure in a warm mould, and subsequently cut more economically than the irregular lumps of crude rubber hitherto used. The little arrangement, called a "pickle" or "masticator," on which this experiment was made, could deal with a charge of only two ounces of rubber; it is nevertheless the prototype of our modern rubber mill, and its invention in 1820 supplies a memorable date in the history of the rubber industry. By itself, however, this discovery did little beyond solving the problem of the disposal of the waste material of the inventor's factory in Goswell Road, London, where, incidentally, the business still flourishes under the style of "James Lyne Hancock, Ltd.," and giving rise to the process of "compounding" rubber with pigments and other ingredients.

In conjunction with the work of Charles Macintosh, however, it was soon to lay the foundation of the rubber proofing industry, and to lead to an enormous increase in the hitherto limited number of purposes for which rubber could be usefully employed.

In the year 1819 Macintosh contracted with the Glasgow Gas Works to purchase their by-products for a term of years, and it apparently occurred to him to test the suitability of coal tar naphtha for the preparation of solutions of rubber for the practical purpose of waterproofing cloth, and to enclose the resultant adhesive film of rubber between two plies of fabric. He speedily realised that he had made an important discovery, and without delay he took out a patent.* The first rubber proofing works were established by him shortly afterwards in Glasgow, but were transferred two or three years later to their present home in Manchester.† Hancock had meanwhile been continuing his investigations, to find new applications for the "masticated" rubber prepared with his machine, the details of which were kept secret until about 1832,‡ and soon discovered the fact that the dissolution of rubber in turpentine was greatly facilitated by this preparatory treatment.§ Further, he found that a smaller proportion of solvent was needed to prepare the "varnish," and in place of the 10 per cent. solutions of rubber referred to in the Macintosh patent, ones containing a much higher proportion of rubber could be made without affecting the consistency of the resultant "dough." ‖ Hancock obtained a licence in 1825 for the use of this patent,¶ and he and Macintosh, at first independently, later as partners, soon placed on the market a variety of fairly satisfactory proofed goods. It is probable, however, that with the imperfectly refined solvents then available, the rubber proofing retained persistently a considerable proportion of high boiling constituents, and consequently possessed a disagreeable odour and a sticky character. This latter defect was surmounted in the Macintosh patent, by placing the proofing between two plies of textile, such materials then, as now, being known in the trade as "double textures"; but for a considerable period until further progress had been made in the purification of coal tar products,

* Hancock, *Ibid.*, p. 3.

† Thomas Hancock, English Patent No. 4451, April 29th, 1820.

‡ Hancock, *Ibid.*, p. 6, *et seq.*

* Charles Macintosh, English Patent No. 4804, June 17th, 1823.

† Macintosh *v.* Everington & Ellis, *Mechanics' Magazine*, 1836. Vol. XXIV. pp. 460, 469, 489, 508, 529.

‡ Hancock, *Ibid.*, p. 16.

§ Hancock, *Ibid.*, p. 20.

‖ Hancock, *Ibid.*, p. 23.

¶ Hancock actually employed for his work a mixture of equal parts of turpentine and coal tar naphtha. Hancock, *Ibid.*, p. 23. Also English Patent No. 5120, March 15th, 1825.

there can be little doubt but that a waterproof garment was a far from inodorous article.

The materials manufactured in these early days possessed another disadvantage, in that they became hard and stiff on keeping or being exposed to cold, and were softened by heat or contact with rubber solvents.

In this connection, however, it must be borne in mind that at the present time certain materials such, for example, as diving dress fabric and cart cover cloth, are almost invariably made up as they would have been in these early days.*

Though a rough mechanical arrangement appears to have been early substituted for the hand brushes by which the solution was initially applied to the fabric, the proofing process continued to be carried out by decidedly primitive methods,† until 1837, when Hancock patented the form of spreading machine which is, with slight modifications, in general use to-day.‡

During the sixteen years' interval between 1823 and 1839 the progress of the industry was merely that of normal healthy development, unmarked by any discovery of fundamental importance.§

Minor problems, such as the construction of waterproof seams, the use of reeds for air-beds and cushions, the injurious effect of dressings in the fabrics on the durability of the proofing, were one by one surmounted; while the steady discovery of fresh and important applications for the new product, amongst which may be cited billiard cushions, deckle straps, machine rollers, cut sheet tubing, brewers hose, etc., made it necessary to devise new machines and processes of manufacture.

We now come to the discovery which was destined to revolutionise the industry, and to raise rubber from being merely a useful waterproofing material to one which now may be said to be almost indispensable in practically every phase of human activity. While the humid climate of Britain resulted in the attention of our early investigators being concentrated on the imitation of the waterproof capes of the South American native, our kindred in the then youthful States of America, probably on account of the greater severity of their winter, were more impressed by the utility of the crude overshoes which were imported into Boston in small quantities from time to time. A single pair of shoes in 1820 constituted the first consignment, three years later the number imported had risen to 500 pairs, and, according to Goodyear,* the yearly average between 1820 and 1855 amounted to no less than 500,000 pairs. The importers and dealers in America appear to have made attempts at an early stage to produce an imitation of the native article, by building shoes up from sheets of rubber imported from Brazil,† and by means of prolonged seasoning these goods seem to have given satisfaction. A similar trade sprang up in England between 1825 and 1830, Hancock's cut sheet being employed for the purpose.‡

By 1829 the developments in Europe resulting from the Macintosh patent had become generally known, and in 1832 John Haskins and Edwin M. Chaffee started the Roxbury India Rubber Company in Massachusetts, with a capital of $400,000, their enterprise being speedily followed by numerous others. Immediate difficulties were encountered, owing to the "adhesive" surface of the spread rubber,§ and frequent decomposition of manufactured articles taking place in the hot weather of the American summer, with the sequel that all these ventures had but a transient existence.‖

Needless to say, the heavy financial losses involved in these unsuccessful undertakings seriously affected public confidence, and for some time after made it difficult for inventors to obtain any measure of support for their schemes or investigations. At this unpropitious moment, Charles Goodyear, a hardware merchant, took up the problem. Undeterred by failures, public

* Hancock (*Ibid.*, p. 139) says: "It has been thought that rubber before the discovery of vulcanisation had scarcely been brought into any extensive use; the fact that we were using from three to four tons a week as early as 1837, 1838 is proof of its usefulness in its unvulcanised state."

† Hancock's factory was destroyed by fire on April 11th, 1834, as a result of proofing being carried out by candle-light. In 1838 the Macintosh works suffered a similar fate.

‡ Thomas Hancock, English Patent No. 7344, April 18th, 1837.

§ It is, perhaps, of interest to record in passing that during this period the first rubber factory in France was established, in 1828, by Messrs. Rattier et Guibal at St. Denis, near Paris, under Hancock's personal supervision. Hancock, *Ibid.*, p. 63.

* Charles Goodyear, "Gum Elastic," New Haven. 1855. Vol. I. p. 43, 44, 45; Vol. II. p. 317.

† Goodyear, *Ibid.*, p. 53.

‡ Hancock, *Ibid.*, p. 62.

§ It would appear probable from Goodyear's remarks that turpentine was the only technical rubber solvent available in America at this period.

‖ The Roxbury Company was in a measure more successful than its imitators, owing to Chaffee discovering that thin sheets of rubber could be prepared by mechanical means alone. His machine, known as the "Mammoth," may be regarded as the forerunner of the modern calendar. (Goodyear, *Ibid.*, pp. 54, 100.) The improvement effected was, however, merely superficial, and only postponed his firm's failure, which took place in 1836. (Goodyear, *Ibid.*, p. 111.)

indifference, and occasionally actual want, he finally succeeded in overcoming all the difficulties which had hitherto been experienced, and produced articles of rubber which were non-adhesive, tough, durable, and unaffected by the heat of summer, the cold of winter, or the action of ordinary rubber solvents. Goodyear first tried the effect of compounding the rubber with an equal proportion of magnesia, and found that the initial "tack" of the surface was considerably reduced.* He subsequently found that this result could be enhanced by the substitution of lime for magnesia, or by after-treating the mixing containing the latter with lime water; but white shoes made from these compounds soon showed signs of softening in warm weather, thus showing the improvement to be merely superficial.†

During one of these preliminary experiments Goodyear attempted to remove some metallic powder from the rubber surface by treatment with nitric acid, and noticed that this produced the desired toughening effect. From this observation was evolved the so-called "acid gas process," which would seem to have been carried out by dipping the goods into a solution of dilute nitric acid, followed by immersion in a bath containing bleaching powder.‡

A patent § was taken out in America for this process, and during 1837 the inventor disposed of licences to several companies, and on the proceeds of these transactions he himself started a factory.

The result, however, proved to be disastrous, all the goods manufactured decomposing during the summer, with the consequence that Goodyear's plant and effects at Woburn, Massachusets, had to be sold to satisfy his customers' claims for compensation. During this unfortunate venture, however, there was laid the foundation of subsequent success.

One of his employees, Nathaniel Hayward, who had acted as foreman to the previous occupants of the factory, had some time before proposed the use of sulphur as a compounding ingredient for rubber mixings; but his suggestion had not been considered of any value. During his experiments, however, he had noticed that exposure to sunlight produced an abnormal effect on rubber goods when this ingredient was present, and on communicating this observation to his new employer, the latter thought the matter worthy of investigation. Finding that this procedure resulted in a product possessing a dry tough surface, Goodyear acquired the patent,* which Hayward, at his suggestion, had taken out in 1839 for sulphur as a compounding agent.† Though soon reduced to extreme poverty and want, Goodyear steadfastly continued his investigations, and probably with a view to securing some rapid method of testing the durability of his rubber mixings, he tried the effect produced by subjecting these to the heat from a stove or open fire. As he suspected that his failure with the "acid gas process" had been caused by the use of white lead in the mixing, he was probably anxious to ascertain whether this ingredient would have the same detrimental effect if employed in connection with his newly acquired "solarizing" or "sun-curing" process. To his surprise the rubber, instead of softening and melting under the influence of heat, became greatly altered in its properties, and following up this observation during the winter of 1839–40, employing at one time steam, at another hot air as source of heat, Goodyear realised that he had at last successfully accomplished the task to which he had devoted so much time and labour.‡

The discoverer's troubles were, however, far from being at an end. The unfortunate events of the previous few years had made the public cautious, and several years elapsed before he could obtain the assistance necessary, either to patenting his discovery or to applying this new process on a commercial scale.

On December 6th, 1841, however, a claim of invention was lodged in the U.S. Patent Office, and by 1843 a definite application for a patent was made by Goodyear simultaneously in America, England and France.§ During the interval in 1842, Goodyear had sent a representative to Europe with a view to enlisting the

* Goodyear, *Ibid.*, p. 102.

† Goodyear, *Ibid.*, p. 104.

‡ Goodyear, *Ibid.*, p. 165.

§ Charles Goodyear, United States Patent No. 240, June 17th, 1837. There appears to be no foundation for Goodyear's allegation (*Ibid.*, pp. 107, 108) that Thomas Hancock patented this process without acknowledgment in England, subsequent to a visit from Dr. Joseph Bradshaw, who had undertaken to open negotiations in Europe on behalf of the discoverer. The use of oxides of nitrogen amongst other compounds for vulcanisation of rubber was, however, subsequently claimed by Parkes in English Patent No. 11147/1846, and as regards gutta percha by Charles Hancock in English Patent No. 11575/1847.

* Nathaniel Hayward, United States Patent No. 1090, February 24th, 1839. Goodyear, *Ibid.*, pp. 113, 73, 164.

† The employment of sulphur as a compounding agent is credited to the German chemist Ludersdorf in 1832, and its use for this purpose is claimed by Fanshawe in English Patent No. 9189/1841.

‡ Goodyear, *Ibid.*, p. 119.

§ Goodyear, *Ibid.*, pp. 86, 87. Newton, English Patent No. 10027, January 30th, 1844. Charles Goodyear, United States Patent No. 3633, June 15th, 1844.

support of Macintosh and Company, and other firms. His agent—Mr. Moulton, an Englishman resident in America—was entrusted with samples to show the results obtained by the process, but was left in ignorance of the means by which the effect was obtained, Goodyear evidently being under the impression that the trade prejudice against subjecting rubber goods to heat was sufficient to ensure the safety of his secret. In this he was mistaken. The negotiations with the Macintosh Company ultimately came to nothing, but his agent nevertheless allowed them to retain the samples which they had been given as specimens.*

Portions of these samples, in which the presence of sulphur had been quickly detected by Mr. Woodcock, Messrs. Macintosh's works manager, came into the possession of Thomas Hancock,† who, appreciating their valuable qualities, immediately set to work to devise means to secure the same result. Hancock did not have the samples analysed, probably from motives of secrecy, and relied solely on his long technical experience to solve the problem.

Though from the beginning he suspected that heat played a part in producing the change, after many experiments, in which mixtures containing sulphur were frequently employed, he failed to reproduce satisfactorily the desired properties,‡ probably owing to his heating having been insufficiently long or intense to effect, in the absence of lead compounds, what is now known as "vulcanisation." §

In some of the heated samples containing sulphur, however, a slight superiority became evident on keeping them exposed to cold, and, on the strength of this observation, Hancock lodged an application for a patent on November 21st, 1843,‖ which allowed him six months to work out the details of his final specification. It soon occurred to him to see what effect would be produced by immersing strips of pure rubber in molten sulphur for varying periods of time. On removing the samples from the bath they were, to his great satisfaction, remarkably improved in strength and elasticity, and withstood exposure to low temperature and to the action of rubber solvents in the same way as did the specimens which he had set out to imitate. He, moreover, observed that, on prolonging the treatment, the rubber became tough and horny, and black in colour, and that these results could be secured equally well by incorporating the sulphur with the rubber, and subsequently subjecting the mixture to the action of heat.

During the subsequent investigations, prior to the enrolment of the final specification, Hancock appears to have obtained scientific assistance, and to have made use of the greater technical facilities afforded by the Macintosh Works at Manchester.

It probably occurred to him, as it did to Goodyear, that substances other than sulphur might exist capable of producing a similar effect,* and it is possibly with this object that he also consulted Professor Graham—later famous for his pioneer work on the properties of colloids —who occupied the Chair of Chemistry at the then London University College. It was, however, not long before this possibility was realised by another inventor, Alexander Parkes, who discovered that by dipping rubber goods into a solution of sulphur monochloride in carbon disulphide, the desired change could be effected rapidly without use of heat A patent † was taken out for this "cold cure" process on March 25th, 1846. It is somewhat remarkable that Parkes, while suggesting the use of a variety of gases for the same purpose, overlooked what would seem the obvious possibility of employing the vapour of sulphur chloride in the same way, and that it was not until thirty-two years later that the convenient modification of his process, known as the "vapour cure," was introduced.‡

Before considering the developments which were made possible by these discoveries, it is perhaps well to stop to consider their nature, and the relative amount of credit due to the several inventors.

To Goodyear, undoubtedly, must be ascribed

* Hancock *v.* Sumervil & Burr. Newton's *London Journal.* Vol. 39, p. 158, *et seq.*

† It would seem that Hancock took no part in the negotiations between Mr. Moulton and Messrs. Macintosh with whom he was associated, but that the samples were given to him subsequently by Mr. Brockedon, one of his co-directors.

‡ Hancock, *Ibid.*, p. 98, *et seq.*

§ To Hancock's colleague Brockedon we owe the word "vulcanisation," by which this process is now universally known. The term which was coined to portray the fancied resemblance which the process bore to the flaming forge of classical mythology (Hancock, *Ibid.*, p. 107), is used in English Patent No. 10460, January 11th, 1845, and must therefore have originated prior to this date.

‖ In this provisional application or "deposit paper" no reference was made to the employment of heat, an omission which gave rise to subsequent litigation (*See* Hancock *v.* Sumervil & Burr; also Hancock *v.* Noyes. Common Law Reports. 1854. Vol. II., Part 2). In Goodyear's Patent No. 10027, lodged January 30th, 1844, the two essential conditions of the vulcanisation process are clearly indicated though the presence of lead compounds is also postulated.

* Goodyear, *Ibid.*, p. 86.

† Alexander Parkes, English Patent No. 11147, March, 25th, 1846.

‡ William Abbott, English Patent No. 166, January 14th, 1878.

the honour of having been the first to produce articles of vulcanised rubber. And, moreover, by his having employed white lead in conjunction with sulphur he may be said to have been the first to employ an "accelerator," and to have thereby originated the "dry heat" process of vulcanisation.* By his discoveries the manufacture of rubber boots and shoes, still one of the most important branches of the industry, was placed on a practical basis.

It is Hancock, however, whom we must regard as the "Father of the Rubber Industry." His early work supplied us with the essential technical processes of milling, compounding, moulding and spreading rubber. While he owed his later discoveries in connection with vulcanisation to having seen samples of Goodyear's products, it must not be forgotten that he was ignorant of the means employed to obtain the effect, which in his case was secured by the employment of heat and sulphur alone, and that, moreover, during the course of these experiments the important product, variously known as hard rubber, vulcanite or ebonite, appears to have been produced for the first time.

To the work of these two outstanding pioneers, the discoveries of Macintosh, Chaffee, Parkes and subsequent investigators, contributed only in a minor degree. Since 1844 many changes and improvements may have been effected; but the essential processes employed in the manufacture of rubber goods still remain—those devised by Hancock, Goodyear, and their fellow-workers in these early days.

By 1846 Hancock had made sufficient progress in the technical application of his process to take out a patent for the vulcanisation of rubber in moulds.† Meanwhile, Goodyear's licencees had not been idle, and the following year witnessed the arrival in England of the first consignment of American vulcanised overshoes manufactured by the Hayward Rubber Company of Colchester, Connecticut.‡ Legal proceedings were thereupon instituted by Hancock against the importers for infringement of his patent,

* In the "dry heat" process vulcanisation is secured by hot air at ordinary atmospheric pressure. The "steam heat" process is carried out in steam under pressure, the goods being protected by waterproof wrappings or by immersion in French chalk, while in the "press cure" the heating is effected under pressure in moulds or between plates.

† Thomas Hancock, English Patent No. 11135, March 18th, 1846.

‡ This was founded by the Nathaniel Hayward who had patented sulphur as a compounding agent (Goodyear, *Ibid.*, p. 118). Two other American rubber shoe factories were started in 1845 by Mr. L. Candee at Hamden, Connecticut, and by Mr. William Deforest at Naugatuck (Goodyear, *Ibid.*, Vol. II. p. 317).

and finally an arrangement was come to by which the Hayward Rubber Company, in consideration of a royalty, were granted an exclusive licence to sell their products in the English market.*

Contrary to Hancock's expectations, the popularity of rubber footwear increased by leaps and bounds as the American article was improved in shape, and was given a fine glossy finish by means of an oil varnish, the use of which is possible only with the Goodyear "dry heat" process of vulcanisation, effected with a mixing containing lead compounds. The monopoly of the Hayward Rubber Company in this country naturally became distasteful to the dealers in rubber goods, with the result that they decided to test the legality of Hancock's master patent.

The first case in 1851 resulted in the vindication of Hancock's claims,† and a similar decision was given by the Courts in a second action raised four years later.‡

The position in England during the fourteen years following November, 1843, seems to have been that, while the general process for the vulcanisation of rubber by means of sulphur and heating could be employed only by those licensed under the Hancock patent, the use of a litharge mixing, suitable for the manufacture of overshoes by the "dry heat" process, was still further restricted by the simultaneous existence of the Goodyear patent. It is not surprising, therefore, to find that this branch of the industry remained undeveloped in England during this period, and has subsequently been confined to Scotland and Liverpool, where the first factories of this kind were started under American management.§

* Hancock, *Ibid.*, pp. 127, 142.

† Hancock *v.* Sumervil & Burr, Newton's *London Journal*, Vol. XXXIX. p. 158, *et seq.*

‡ Queen *v.* Hancock & Others, *Mechanics' Magazine*, 1855, Vol. LXIII. p. 80. The case against Hancock's patent was based on three allegations—(a) That the use of sulphur was anticipated in Fanshawe's patent 9189/1841: (b) That vulcanised rubber articles had been sold to the public by Moulton prior to November, 1843: (c) That Hancock had not effected vulcanisation at the time of his application for a patent, and that the necessity for heating the rubber-sulphur mixing was discovered during the interval prior to the filing of the complete specification.

§ The North British Rubber Company was incorporated May 26th, 1857, in Edinburgh, having been founded there in 1855 under the style of "Norris & Co.," the shareholders and management being entirely American (*Chambers's Journal*, September 12th, 1857, p. 165). This enterprise was made possible owing to Hancock not having protected his discovery in Scotland where separate registration was necessary under the old Patent Laws. It is perhaps interesting to note that Norris & Co. acquired both the Scottish and English rights of Goodyear's patent as relating to footwear, the latter, however, subject to a condition permitting the firm of Hutchinson, Henderson & Co. to import shoes

Between 1857–1860 the essential processes of the industry became common property, and this point is an opportune one, therefore, to take stock of the progress made during the first period of its existence, with a view to contrasting the conditions then with those which obtain to-day

Anyone studying Hancock's and Goodyear's books in conjunction with the abstracts of patents issued by the Patent Office, cannot fail to be struck by the little change which has taken place in factory practice and products during the past sixty years. The preparation of the rubber, the compounding ingredients, the general process of manufacture, and the methods of vulcanisation at present in use, presented little or no fundamental difference from those employed in the early days. Though enormous changes have taken place in the character of the industry, these have in the main been in connection with the increased output and modified types of goods demanded by the spread of civilisation, increase in the world's population, better communications, and, above all, by the striking developments which have occurred in almost every other branch of industry.

Of these industrial changes two, which have had far-reaching effects on the rubber trade, could scarcely have been foreseen, namely, the advent of the internal-combustion engine for mechanical transport,* and the manifold applications for electricity.† The former has created two new branches of the industry of outstanding importance in the manufacture of solid and pneumatic motor tyres,‡ the latter has greatly extended the field of the vulcanite factory beyond the limited range of small articles such as combs and razor scales, which in the earlier days formed its staple output. Together these two must have totally falsified any early prediction regarding the world's present crude rubber consumption, based on however liberal an estimate. That a demand for rubber might arise beyond the capacity of existing sources of supply was clearly foreseen, however, by Thomas Hancock in 1855, and his remarks are of such historical interest that they deserve reproduction verbatim. He says: "I some time since, through the medium of the 'Gardener's Chronicle,' * called attention to the possibility of cultivating the best kinds of caoutchouc-bearing plants in the East and West Indies; the *Siphonia elastica* of the River Amazon, the *Hancornia speciosa* of Pernambuco, and the *Urceola elastica* of Borneo, Pulo-Penang, and other islands. From the best information I have been able to obtain, there is every probability of success, and as this substance is now become an article of large and increasing consumption, plantations of these trees may, in a few years, produce a beneficial return. We cannot look far into futurity, but if by any chance the present source of supply should be cut off or obstructed, another source would be of great importance; at all events, the subject should not be lost sight of, and I mention it here in the hope that the suggestion may meet the eye of some one who may be disposed to make the trial. Sir W. Hooker † has been so kind as to say that he would at any time render any assistance in his power to parties disposed to make the attempt."‡

Whatever may have been the shortcomings of science in respect to other branches of British industry, it must be placed to its credit that the needs of the rubber trade received not only sympathetic attention, but practical assistance from Sir Joseph Hooker, Director of Kew Gardens, when at length, in 1876, a favourable opportunity presented itself to make a trial of Hancock's suggestion. The romantic history of the introduction of the *Hevea braziliensis* is too well known to need recapitulation,§ but the events of the last four anxious years have enabled us all to appreciate more fully the debt of gratitude which the British Empire,

manufactured by them in France on payment of a royalty of 1 cent. per pair. The Liverpool Rubber Company was founded in 1859 by an American—Wm. Somerville—after the lapse of the Hancock patent. For additional information concerning individual companies and details regarding the development of plant and technique, the quarter century number of the *India Rubber Journal*, 1909, should be consulted.

* Walter Hancock, a brother of Thomas Hancock, was one of the pioneers to introduce the use of steam carriages on the high road, while a nephew of the same name, for many years a member of this Society, later played a prominent part in promoting the legislation which made possible the development of automobilism in this country. (*Journal of the Royal Society of Arts*, 1916, p. 849.)

† At the time when Hancock and Goodyear were laying the technical foundations of the modern rubber industry, Michael Faraday, Professor at the Royal Institution, was making the scientific discoveries which form the basis of modern electrical practice.

‡ For an historical survey of the development of the motor tyre, see Pearson, "Rubber Tyres and all about them," Chap. VI. The first patent for a pneumatic tyre was that of R. W. Thomson, No. 10990/1845.

* The *Gardener's Chronicle*, May 12th, 1855, p. 318.

† Sir William Jackson Hooker (1785–1865) was Director of the Royal Botanic Gardens at Kew from 1841 to 1865, when he was succeeded by his son Sir Joseph Dalton Hooker (1817–1911), who occupied the post until 1885. It is remarkable that the notice of the latter's life and work in "The Dictionary of National Biography" contains no reference to the important *rôle* which he and Kew Gardens played in the introduction of the *Hevea braziliensis* into the East.

‡ Thomas Hancock, *Ibid.*, pp. 76, 77.

§ H. A. Wickham, "On the Plantation, Cultivation and Curing of Para Indian Rubber." 1908.

not less than the rubber industry, owes to the enterprise of Wickham, Sir Joseph Hooker, and Sir Clements Markham of the India Office in this connection.

While Britain still retains a predominant position in the rubber world, conditions have changed since Hancock's time, and to-day it is as a rubber producer, and not as a manufacturer, that this country is in the forefront.

That such is the case may be judged from the fact that of the world's supply of raw rubber it is estimated that between 70 per cent. and 80 per cent. is now produced within the Empire as a direct consequence of the foresight of Wickham and the enterprise of British capital.

When, however, we examine the statistics for the distribution of this valuable raw material the figures furnish little ground for self-congratulation. This will be evident from the following table showing the consumption of rubber in 1917, in which is included an estimate of the value of the trade resulting from its use, based on the assumption that every 1,000 tons of crude rubber represent goods to the value of £1,000,000.

Consumer.	Population.	Quantity in tons.	Per cent.	Productive value.
				£
United States	92,000,000	177,088	69·0	177,000,000
Great Britain	45,000,000	25,983	10·2	26,000,000
France	40,000,000	17,000	6·7	17,000,000
Italy	35,000,000	9,000	3·5	9,000,000
Russia	174,000,000	7,500	3·0	7,500,000
Canada	7,000,000	6,287	2·7	6,300,000
Scandinavia	—	5,323	1·9	5,300,000
Japan and Australia	—	4,500	1·8	4,500,000
Germany and Austria	117,000,000	3,000	1·2	3,000,000

It is therefore evident that while the British trade is second in importance, it is insignificant compared with that of the United States.

Speaking recently on this subject the chairman of the United States Rubber Co. made the following striking comments.* "The value of the rubber manufactures in the United States for the year 1917 was nine hundred million dollars. This is approximately seven times as much as the value in the next largest manufacturing country, and more than twice as much as the rest of the world put together. In ten years the United States has increased its consumption of crude rubber from 24,000 to 177,000 tons, while Great Britain, the next largest manufacturer, increased from 14,000 to 26,000 tons. While Great Britain was doubling her consumption we multiplied ours by nearly seven and a half."

* *India Rubber World*, January 1st, 1919, p. 207.

Though some part of this remarkable expansion of the American trade may be due to circumstances arising out of the war and exceptional conditions in its home market, the fact remains that the British manufacturer has latterly fallen far behind in the race for industrial supremacy, and he will now need to strain every nerve to regain his former position.*

Allowing that the efforts of its powerful competitor must be materially assisted by the economies resulting from large-scale and specialised production,† the first care of the British rubber industry should be its own technical efficiency, upon which success primarily depends.

When we consider that the population of the Empire is estimated at over 400 millions, or one quarter that of the entire world, ample scope should exist for future expansion, whether it be by an increased export trade from Great Britain or by the development of manufacture in its colonies and dependencies.‡

To avail himself of this almost undeveloped field, and to compete in the other markets of the world, it is essential that the goods of the British manufacturer should be at least equal to those of his competitors in price, quality and finish: unless these three conditions are satisfied

* While a large proportion of the American production of manufactured rubber is retained for domestic consumption, more especially in connection with the requirements of its important motor industry, since the outbreak of war its export trade has made notable progress in the fields in which, prior to the war, the European manufacturers were holding their own. For example, the import of American tyres into Britain rose from £231,096 in 1913–14 to £2,097,215 in 1915–16, and in colonial markets the increase was even more marked.

† One American factory has a daily output of 20,000 motor tyres, while the United States Rubber Company controls the operations of no less than forty-seven separate works.

‡ Of the products of the British industry, the proportion exported is approximately one-third of the whole.

commercial enterprise and propaganda can be of little service.

At two critical points in its history it must be admitted that Providence has dealt kindly with the trade. When in the early days the advent of railways and steamships gave rise to a demand for mechanical rubber goods the discovery of vulcanisation enabled the want to be satisfied. Later, when the supply of wild rubber threatened to be insufficient to meet the needs of the new-born motor industry, the plantation product was at hand to fill the shortage. On each occasion the industry has owed its ultimate success, not to its own efforts, but to the enterprise and foresight of two outside individuals—one an ironmonger, the other a Government official. Had it not been for their intervention there can be little doubt but that the development of the rubber and many other associated trades must have been greatly retarded. The conditions of modern industry, moreover, differ vastly from those of the last generation, and important discoveries of an accidental character are no longer the common occurrence which they were when many processes were in their infancy. To borrow a metaphor from the miner, the surface workings may be said to have become exhausted, and it remains either to look for seams at deeper levels or to pick over the materials thrown aside as valueless in the past.

In future, therefore, the solution of industrial problems can no longer be left to chance, nor can improvements be expected to result from the employment of obsolete methods. Though by the test of long experience the processes of the rubber industry must be admitted to be reasonably efficient, yet during its later years the inventiveness of the trade has not been stimulated by any long period of adversity, and it would be idle to contend that its technique or products have reached finality. If, therefore, the British manufacturer is to compete with his rivals in the markets of the world with reasonable prospects of success, he will need to face these facts and adapt his works to meet existing conditions.

To this end the work of the practical man of the early days will have to be supplemented by the modern trained specialist, since the data necessary for developing factory control, evolving new processes of manufacture and devising fresh applications for rubber, can be obtained only by systematic and careful research into the chemical and physical properties of caoutchouc and other colloids.

Such being the general position of the industry to-day, we can now consider some of its technical aspects in more detail.

Of what might be termed the essential raw materials of the rubber manufacturer, rubber and cotton are the most important. Both these are of botanic origin, and supplies are consequently subject to fluctuations as a result of climatic, mycological or economic causes. They are, moreover, the produce of other lands, and their importation is dependent on adequate shipping facilities and free access to our ports, factors on which it is scarcely necessary to dwell at the present time. The problems of the cotton industry have recently received a considerable amount of attention,* and it will suffice to say that any practical scheme having as object the improvement either in the quality or yield of cotton, the resistance of the plant to disease or climatic influence, or the extension of its cultivation within the Empire, must be a matter closely touching the interests of the rubber manufacturer.†

So far as rubber is concerned, the industry would seem to have no ground for anxiety for the future on the score of cheap and plentiful supplies.

The output of the plantations is steadily increasing whilst the scientific problems incidental to the production of a uniform high-grade product are receiving careful attention, both by British and Dutch research institutions, and means should soon be available to eliminate all ground for complaint on the part of the consumer.‡

Adequate consideration is being given to the well-being of the tree, so that the possibility of failure in the yield of rubber due to disease would seem to be remote. Granted that the situation as regards crude rubber appears

* Lawrence Balls, "Some Applications of Research to the Cotton Industry," *Journal of the Royal Society of Arts*, May 3rd, 1918, p. 389. G. C. Dudgeon, "The Maintenance of the Quality of Egyptian Cotton," *Bulletin* of the Imperial Institute, Vol. XVI. p. 160.

† It is, moreover, possible that future developments in the artificial silk industry may provide from wood cellulose a substitute for cotton to which the manufacturer can resort in times of shortage or high prices. (L. P. Wilson, "The Artificial Silk Industry," *Journal of the Society of the Chemical Industry*, 1917, p. 817.)

‡ The chief criticism which has been made regarding plantation rubber is in connection with its variability in vulcanising properties. (W. A. Williams, "The Advantages and Defects of Plantation Rubber." "Rubber Industry," 1914, p. 284.) Its milling qualities would also seem to be less uniform than those of Para. It should be mentioned that the greater cleanliness of the plantation product presents a very satisfactory contrast to wild rubber. The impurities in the latter were one of the difficulties with which early workers had first to contend. (Hancock, *Ibid.*, p. 76.)

eminently satisfactory, it would nevertheless be unwise to neglect any precautions to ensure an alternative source of supply in the event of some unforeseen reduction taking place in the output of natural rubber. The rubber trade, therefore, might well contemplate the future and decide whether the risks incidental to existing conditions are sufficient to justify, on commercial and national grounds, the cost of an investigation into the synthesis of rubber, an undertaking which, however successful it might prove from a scientific standpoint, might nevertheless at the moment be technically impracticable on economic grounds.*

This fascinating problem has already attracted an enormous amount of attention during recent years,† but the objects in view have generally been immediate commercial profits, a state of affairs which is not conducive to the conditions under which research is seen to best advantage. As a consequence, synthesis has been put before analysis, with the result that, despite the incentive of urgent war needs, the best scientific talent of Germany has failed to supply an artificial substitute to replace adequately the unavailable natural product.‡ Although the immediate result sought for has not been attained, their investigations have led indirectly to the discovery of the basic organic accelerator of vulcanisation. That the synthesis of rubber will be ultimately accomplished there can be but little doubt. This notable achievement, however, probably will be withheld from the chemist until the fundamental properties of colloids and the constitution of caoutchouc are more clearly understood.

The difficult nature of the investigation, the lessons of past failures, and the prosperous condition of the plantation industry meanwhile must act as a deterrent to individual enterprise, and render the problem one which, like afforestation, can be taken up only by the nation or the trade as a whole.

There is one other potential source of rubber which deserves consideration, namely, that contained in the vulcanised waste materials which at present form the basis of the manufacturers' supply of reclaimed rubber. No process hitherto has been evolved by which a product can be made from waste rubber which is reasonably comparable in physical properties with one of equivalent composition prepared from fresh rubber.

Reclaimed rubber is nevertheless an exceedingly useful ingredient for goods in which mechanical strength is not the first consideration, and consequently its market value is considerably higher than would at first sight seem justified on the basis of rubber content and physical properties.

That rubber waste should form the starting-point for new rubber is therefore unlikely, but scope would seem to exist for improvement in the processes at present employed for its utilisation with the object of securing a product to which revulcanisation might restore a greater measure of its former strength and elasticity.*

We can now turn from the subject of raw materials to the factory itself where the necessity for the application of science in its widest sense is accepted as one of the conditions for modern industrial efficiency. The first problems which here call for solution arise from the fact that the supply of cheap labour enjoyed before the war is now a memory of the past. Manual operations will, therefore, have to be employed more efficiently or supplanted by more rapid mechanical processes if this new condition is not to be reflected in unduly increased costs of production. Economic considerations will also require a greater degree of standardisation in materials and products than has hitherto characterised the trade, and, as in America, must tend to promote specialisation.

---

* There would seem to be considerable analogy in this respect between the rubber and celluloid industries. The latter, in view of the Japanese monopoly of camphor, has devoted a great amount of attention both to the problem of the production of a synthetic substitute and to the search for some other equally satisfactory gelatinising agent for nitrocellulose. ("Nitrocellulose Industry," Worden, Vol. I. Chapter VII.)

† W. H. Perkin, "The Production and Polymerisation of Butadiene, Isoprene, and their Homologues." *Journal of the Society of the Chemical Industry*, 1912, p. 616.—Porritt, "The Chemistry of Rubber," 1913, Chapter VI.—B. D. W. Luff, "Some Aspects of the Synthesis of Caoutchouc," *Journal of the Society of the Chemical Industry*, 1916, p. 983.

‡ Sufficient progress appears to have been made in Germany to produce satisfactory ebonite from a synthetic raw material (*India Rubber Journal*, September 7th, 1918, p. 227); but for purposes for which soft rubber is necessary no artificial substitute has as yet been encountered in any way comparable with the natural product in strength and durability. It would be interesting to know whether the investigations of the Bayer Company into the synthesis of caoutchouc were dictated by an intelligent anticipation of the impending war.

* As an illustration, a good quality "alkali" reclaimed, prepared from old motor tyre treads containing about 55 per cent. of rubber, may be cited. This may be purchased at about 9½*d*. per lb., which price, calculated on the rubber content, works out at approximately 17¼*d*. per lb., as compared with new plantation rubber at 25*d*. per lb.

The physical properties may be judged by the following comparative figures :—

	Breaking load. Lb. to sq. in.	Elongation 3-in. test piece
Original stock	1,760	20·5
Revulcanised reclaimed	400	7·5

Whatever may be done to simplify the processes of manufacture and to reduce unnecessary labour by the elimination of what have been termed "wheel-barrow and shovel" methods, the rubber manufacturer will, nevertheless, still be largely dependent on the skill of his workers for the quality and finish of his goods and for the reduction of wastage to a minimum.

The success which may attend the efforts of the trade in treating the problems presented by the human factor will therefore have much to do with the continued prosperity of the industry.

While unnecessary labour will have to be eliminated, that which is essential should be made more efficient. With this object increased attention will have to be paid to the various factors which will occur to the works manager as likely to promote the health and well-being of his employees.*

The psychological problems of modern management call for even more careful attention. In the smaller factories of Hancock's time the manager could be known personally to all his employees, and that *esprit de corps* and feeling of community of interest so necessary to the efficiency of any organisation could be secured by the exercise of reasonable tact and fair dealing.

The large and complex organisations which have arisen to meet modern industrial requirements have resulted in a lessening of the sympathy between employer and employed, which characterised these early days, and the restoration of a better understanding between these two is probably our most important and urgent national problem, not only in the rubber trade, but for industry as a whole.†

The rubber factory has, in addition, its own special problems, mainly arising from the fact that its supplies, processes and products are not at present susceptible to the same measure of scientific control as those in most other industries. Slight variations in the raw materials, the methods of manufacture, or in the conditions of vulcanisation, may pass unnoticed for months until customers' complaints show that the finished article is faulty. In the absence of any satisfactory quick test to determine the durability of his goods before they leave the factory,* it is not surprising that the rubber manufacturer generally has adopted the motto *festina lente*, and prefers to follow the safe policy of adhering somewhat slavishly to conditions of manufacture which experience has shown to be least liable to result in monetary loss or damage to trade reputation.

This, of necessity, renders the industry as a whole somewhat slow to respond to alterations in industrial requirements or to adopt new ideas, materials, and processes; but a conservative policy must persist until such time as the conditions of manufacture become less empirical and are based on well ascertained fundamental principles. The rubber works chemist during the last few years has done much to systematise and control factory operations. He has eliminated many of the mysterious troubles which formerly were rightly or wrongly attributed to the raw materials, and which used to make the factory buyer exceedingly chary of exercising any commercial discretion in his selection of sources of supply. But for his aid the industry must have been hard put to it to adapt itself to the abnormal conditions resulting from the war. Is it, therefore, asking too much to expect the manufacturer to recognise this work, and by the encouragement of research to provide the means by which it may be rendered yet more valuable?

Having traced the development of the industry from its beginning to its present important position, and noted that it has owed its origin and the greater part of its technical processes to British enterprise and ingenuity, it is only natural in conclusion to turn to the future prospects of the trade in this country.

The Empire provides, as we have seen, not only an ample supply of raw material, but a potential market of almost limitless possibilities in which a steadily increasing demand for goods is guaranteed by our past record as a pioneer and administrator. In exploiting this field the rubber trade may count on the aid of the motor industry, which, stimulated by the lessons of the war, and assisted by ample supplies of petroleum and benzene, can hardly fail to make rapid strides both at home and overseas.† Could greater incentive exist to induce manufacturers

* Amongst these one might instance as examples the illumination and ventilation of the workrooms, the elimination of fatigue on heavy or monotonous work, the institution of canteens to supply wholesome food, the encouragement of technical education, and the provision of clubs to promote social intercourse.

† A Joint Industrial Council of the Rubber Manufacturing Industry has recently been set up as provided for by the Whitley Report. (*India Rubber Journal*, October 26th, 1918, p. 499.)

* Recent investigations indicate that the coefficient of vulcanisation affords valuable information regarding the durability of rubber goods. (H. P. Stevens, "The Ageing of Vulcanised Plantation Rubber." *Journal of the Society of the Chemical Industry*, 1918, Transactions, pp. 305, 340.)

† It is estimated that no less than 70 per cent. of the United States imports of crude rubber are consumed in the manufacture of solid and pneumatic motor tyress. (*India Rubber Journal*, August 24th, 1918, p. 215.)

to conform to present conditions and to co-operate in the conquest of new markets and the defence of their old ones?

To our record in the past an American journal has testified recently in the following terms:—"That the British have ever been great and enterprising merchants none can deny. They have also been honest and above board in their merchandising. If now they use in manufacture the conspicuous ability shown in quantity production of war material they will indeed be competitors hard to beat."*

If, therefore, it but fulfils the estimates which others have formed of its ability, there is every prospect that the rubber trade may soon occupy an exalted position amongst the industries of our country, and one worthy of the high traditions inherited from its founders.

I have to express my great indebtedness to Mr. J. Hancock Nunn, to Mr. Alexander Johnston, and the management of the North British Rubber Co., Ltd., and to the officials of the Advocates' Library, Edinburgh, for assistance in compiling the subject-matter of this paper.

DISCUSSION.

The Chairman (Professor Wyndham R. Dunstan, C.M.G., F.R.S.), in opening the discussion, said that in the first part of the paper the author had given a very attractive picture of the history of the great rubber industry, with which the name of Hancock would always be connected. It presented a striking picture of our national characteristics of individual enterprise, perseverance under great difficulties, and final success. He feared that just at the present time there was a danger that those characteristics might be somewhat checked at a period when the State was assuming responsibilities in new directions, and he thought it behoved everybody connected with the industry in its various aspects to encourage individual enterprise and new ideas on the part of all its employees. In the second part of the paper the author had given an illuminating picture of the modern manufacturing industry. He had also touched upon the great producing industry, with which he (the Chairman) had been more particularly connected for a good many years. The author had stated that the Empire was already the greatest producer of rubber. At present the amount produced was sufficient, or more than sufficient, for our own needs; but it was satisfactory to know that should further expansion be required it could also be provided within the Empire. He would like to mention two places as possible sources for any additional supply of raw rubber which might be needed. One was Burma, still a largely undeveloped country where the rubber tree grew well, and which was not far removed from the great rubber-producing industry in British Malaya. The other was West Africa, in certain districts of which the rubber tree also grew well, but where, chiefly for economic reasons, not very much progress had been made with the industry. He thought it might be said, therefore, that the Empire was not only producing enough rubber for its own needs and more, but if need be it could produce enough rubber to supply the whole world. In that connection Mr. Porritt had raised a doubt, and quite reasonably, on the desirability of the manufacturing industry depending upon one single source of supply, and he had suggested that in order to have a second source it would be well that further research should be undertaken into the chemistry of caoutchouc, and particularly into the synthesis of rubber. He (the Chairman) had every sympathy with such a research from the scientific point of view, and it was undoubtedly work which must be and would be undertaken. At the same time he did not himself take a very sanguine view of the possibilities of synthetic rubber, provided that the low cost of production of plantation rubber was maintained. Even supposing that synthetic rubber could be obtained equal in quality to the natural material, so long as the plantations could produce rubber as cheaply as it was believed that they could, there seemed to be not very much cause for apprehension from the competition of a synthetic material. Turning to the plantation industry, he thought everyone would agree that it was really in a thoroughly sound position at the present time. There was only one menace, which, fortunately, had not yet attained any formidable dimensions, and that was disease. But those concerned with the planting of rubber were fully alive to that danger, and he felt certain that they would succeed in averting any real danger from that source. Passing to the question of manufacture, Mr. Porritt had brought to the notice of the meeting the predominant position which the United States now held as a rubber manufacturer. It was at present the greatest rubber-manufacturing country in the world, and there was no doubt that the circumstances of the war had greatly assisted it to attain that position. That was a situation which we could hardly regard with equanimity. There were numerous causes, which he could not go into at that moment, which accounted to a large extent for the economic predominance of the United States in that connection. He might refer to one, viz., the extraordinary growth of the motor-car industry in the United States, which was very closely connected with the rubber manufacturing industry. It might be hoped that developments in the near future in the motor-car industry of this country might have an important influence upon the future of rubber manufacture; but it was clear, as Mr. Porritt had told the meeting, that some further action was necessary. Most of those present were aware, no doubt, that some of the larger rubber-manufacturing companies in the United States had acquired estates in the tropics on which they were growing the greater

* *India Rubber World*, January 1st, 1919, p. 178.

part of the rubber that they needed, and they were also aware that some British companies had taken the same step. It was perhaps too early to forecast the success of that combination, but he (the Chairman) gathered that the general feeling among manufacturers of this country was that it was better to leave the growth and production of rubber to those who could devote their entire attention to it as a separate industry. At the same time he would plead for closer co-operation between the two branches of that great industry. There was just one other aspect of the question to which he would like to direct the attention of the meeting—it had already been touched upon by Mr. Porritt—and that was the position of our Dominions. Whether we liked it or not, those new nations had made up their minds that they wished to have great manufacturing industries of their own. In perfect loyalty and friendship with the Mother Country they were pointing to that as a necessity for their development, and what they asked was that in starting these industries they should have the assistance of British capital, and in some cases suggested that branches of big manufacturing companies in this country should be established with them. The time was approaching—in fact had already approached—when that movement would see a considerable extension, and we in this country had to remember that the material that would be used would be British rubber produced in British countries, and carried, it was to be hoped, in British ships to those Dominions. South Africa and Australia were not far removed from the rubber estates. Canada was at a somewhat greater distance, but that surely could not account for the fact that some of the most important rubber-manufacturing companies in Canada were financed with American capital, and that some of those companies were American-owned. He (the Chairman) happened to be in somewhat close touch with that movement in the Dominions, and his own view was that it was a matter which required the most earnest consideration from both producers and manufacturers of rubber at home. Lastly, he would just like to say a word about the question of investigation and research. He thought it was clear that a much more important work could be carried out, as it was being carried out by the company with which Mr. Porritt was connected, in the laboratories attached to the factories themselves, and there was a large chance for the employment of individuality and enterprise in connection with the various companies which, in a friendly way, were competing with each other in the manufacture of rubber. There was another large class of problems, which were best dealt with at the universities as matters of more purely scientific research in connection with the various sciences to which they belonged, chiefly chemistry and physics. The same applied to the plantations, where there was a very large amount of work which could be done by organisations for investigation promoted by the planting companies themselves, and in addition there were a large number of problems which belonged more strictly to the domain of science, and required investigation from a different point of view. When it was remembered that next to nothing was known about the nature of latex, or of the coagulation of that latex into rubber, and that there was still much to learn about the nature of vulcanisation, one realised how much there was to be done, and what a great field the rubber industry provided in both its branches for systematic research.

Sir Edward Rosling said there were only two observations he would like to make. One was that, as a producer, he hoped the manufacturers would soon largely increase their output of material, and the other was he trusted that there would be closer co-operation between the manufacturers and the producers. He knew that the firm with which the author was connected had done a great deal already in co-operating with one research committee. Personally, he realised what a great assistance it was, from a producer's point of view, to get the outlook from the manufacturer's side, and the closer the manufacturers could work with the producers the better it would be for all.

Mr. H. A. Wickham acknowledged his appreciation of the very kindly references which had been made to him. The paper was so largely a manufacturer's one, that he, as a simple planter and forester, could hardly find much to say; but there was one point he would like to lay some stress upon—namely, the risk impending over the existing sources of plantation supply. He had always felt that an altogether too close method of planting had hitherto been employed. A tree like the rubber tree required at least a half-chain spacing, and in his opinion if that measurement had been adopted on the older estates, they would have yielded a much greater return. The existing output per acre seemed to him altogether too low for the age of the trees in most of the Eastern States.

Dr. H. P. Stevens said there were a few technical matters which he might refer to, but would defer the threshing out of those points with the author to a later date.

Dr. S. S. Pickles was surprised at the author's bravery in tackling a subject like the rubber industry, past and present, in one paper, but Mr. Porritt had covered the ground very well. The early days of the rubber industry were extremely interesting, and that vital period which the author had told them something about would have an interest for very many present. On looking round the room he saw many representatives of some of the older firms, such as Macintosh's, Hancock's, etc., whose names were household words in the rubber industry. There was one name which Mr. Porritt had overlooked, namely, that of the late Mr. Stephen Moulton. The author had mentioned in connection with Goodyear's discovery of the process of vulcanisation that an

agent had been sent from America to this country. That agent happened to be Mr. Stephen Moulton, an Englishman, who started very early in the last century—he thought about 1849—and whose works were still running at Stratford-on-Avon. He felt sure that the man who first showed samples to Hancock was none other than Stephen Moulton, the founder of the present firm.

MR. WALTER C. HANCOCK expressed his gratitude for the very complimentary remarks that had been made with reference to the establishment of the industry in this country by his great-uncle, Thomas Hancock. He himself had no justification for addressing such an audience of rubber experts, for his own investigations had been connected with plastic rather than with elastic substances; but there were several points in the paper which struck one as extremely interesting. It had often occurred to him that it was a curious technological fact that some of the substances which were used to such an enormous extent were materials about which, from the purely scientific point of view, especially from the point of view of the chemist or the physicist, relatively little was known. One had only to remember, for instance, how long the constitution of bleaching powder had baffled the attempts of Odling and others, and to remember that despite the investigations of Le Chatelier, the Newberry's and many others, it could still hardly be said that the last word had been heard on the changes which went on in the setting of Portland cement. When one turned to the organic world one could hardly find a better example of that than the question of the caoutchouc test. That led him to the question of synthetic rubber. The production of a number of substances simulating rubber in many of its properties had been carried on for a great many years, but he thought it might be fairly said that up to the present there had been produced nothing which really possessed all those properties associated with a satisfactory raw material. There was also one other point with regard to the question of the necessity of providing for synthetic rubber, and that was that in order to produce sufficient quantities there must be a sufficient supply of raw material. Those who had heard Professor Perkin's address some years ago, before the Society of Chemical Industry, would remember the very exhaustive way in which he had practically attacked the whole problem of a source of supply of organic materials which by any economic process could be converted into synthetic rubber. He (the speaker) knew that the analogy of the indigo industry had been brought forward. It had been asked why, as synthetic indigo had been produced, should not synthetic rubber be produced? He thought those two cases were not quite upon a par; and of course the quantities involved in the one case were, relatively speaking, very small compared to what they would be to produce sufficient rubber to make any serious impression upon the world's markets.

MR. D. F. TWISS pointed out the fact that unfortunately rubber had not fixed properties; its nature was in a state of flux. Its properties could best be described by a curve; they altered from day to day. He had known cases of people who came from plantations, and visited factories in this country, saying, on seeing the rubber which had been sent across from the plantations, "This is not our stuff we sent to you." The properties had so altered during the period of transit that the material was almost unrecognisable. No doubt the nature of synthetic rubber would be very similar to that of ordinary natural rubber, and its properties would alter in the same way. Synthetic rubber had not been altogether successful, but it had been used for certain purposes; and one could always hope that in the future, with improved processes, a better synthetic rubber might be obtained, which would seriously challenge the natural rubber for industrial purposes. On the other hand, when one read the various publications of laboratories on the estates, and laboratories connected with the plantations, it must be realised that finality had not been reached in the production of natural rubber, and that producers of natural rubber were entitled to look forward to improved conditions in the course of the next few years. The prospects of the natural plantations were, he supposed, as bright as ever they had been.

DR. JOHN MCEWAN said that while he was neither a producer nor a manufacturer, but only a connecting link between the two industries, he would like to say that just as the war broke out he was using strenuous efforts to connect those two extremes of the chain. A large body of the most eminent producers had spent several days in one of the prominent rubber works of England, and their intention was almost immediately afterwards to spend several days in the works which the meeting had heard about, on the invitation of Mr. Johnston; but the war came and upset all their plans and schemes. He hoped that now that peace was near it would be possible for Mr. Johnston to renew his invitation, and that a large body of those representing production would go to the north to get the wisdom of Edinburgh, and see for themselves what was being done there. He would like to add to what had been said about synthetic rubber, that it had been a bogey for some time, but they had not felt severely the danger of it. He thought it had never yet been fully realised how largely the inability of Germany to win the war had depended on the fact that she had been shut off from the sources of supply of rubber. It was very commendable that one month after the war was declared, by the efforts of the rubber producers the ports of the United Kingdom were closed to the export of rubber, and it was very doubtful if Germany had been able to get any rubber except in retail and surreptitious ways.

Mr. Porritt, in replying to the various points raised by the speakers, said he was sure that every manufacturer would agree, as also would those who represented the plantation industry, that the closest co-operation was necessary between both branches of the industry. There was one point with regard to research which occurred to him, and that was that as in the manufacturing industry much depended upon technical education, so in order to carry into practice the results obtained by the research carried out at the Imperial Institute, in Ceylon, and the Federated Malay States, education would be necessary for those responsible for the practical management of the estates. He fancied that at the present time the knowledge of forestry among those on the estates was not, perhaps, all that it might be. He quite agreed that the danger of a reduction of the plantation product seemed very remote, but it was not advisable to put all one's eggs in one basket, and that was why he suggested that the synthesis of rubber might be considered. It might have another advantage too. When research work was started, it could never be foreseen what the results would be—one might get what one started out to get, or one might get something of more importance. With regard to Dr. Pickles' remarks, he was happy to be the possessor of that gentleman's report to the British Association on the scientific aspect of rubber, and he could assure him that it was a most useful publication. He agreed with Dr. Pickles as to the difficulty in tracing historical facts, but in dealing with the history of the rubber industry, Messrs Hancock's two law cases had preserved a very large amount of historical information, which would otherwise never have been placed on record; and the same was true of the Macintosh patent. He was also very glad, indeed, to hear what Dr. Pickles had told them of Mr. Moulton. Of that he was sorry to say he was ignorant, and as far as he knew it did not appear in any published work. With regard to what Mr. Hancock had said, he quite agreed that the analogy between the indigo industry and the rubber industry, so far as synthesis was concerned, was a fallacious one. Before the synthesis of indigo was undertaken, the constitution of indigo was thoroughly understood, and therefore to compare that problem with that of synthetic rubber was exceedingly misleading. He agreed with Dr. Twiss that the synthesis of rubber was extremely difficult, particularly with regard to its ageing qualities.

The Chairman proposed a vote of thanks to Mr. Porritt for his valuable paper, and this was carried unanimously.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m. :—

March 19.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light, and Motive Power by Gas and Electricity." The Right Hon. Lord Moulton, G.B.E., K.C.B., F.R.S., will preside.

March 26.—Arnold Hartley Gibson, D.Sc., M.I.Mech.E., Professor of Engineering, University College, Dundee, "British Engineering and Hydro-Electric Development. (The Training of Engineers.)"

April 2.—W. Norman Boase, C.B.E., Chairman of the Flax Committee for Scotland, "The Cultivation and Preparation of Flax, and the Linen Industry." Sir Frank Warner, K.B.E., will preside.

April 9.—Leonard Erskine Hill, M.B., F.R.S., Director, Department of Applied Physiology, Medical Research Committee, "Housing and Infant Mortality."

April 30.—Sir Herbert Jackson, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems." Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside.

May 7. — John Somerville Highfield, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside.

May 14.—H. Kelway-Bamber, M.V.O., "Railway Transport in the United Kingdom."

Indian Section.

Thursday afternoons, at 4.30 p.m. :—

April 3.—Brigadier-General Lord Montagu of Beaulieu, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

Dates to be hereafter announced :—

Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Design in Japanese Art."

J. N. Spencer Williams, "The Hawaiian Islands and their Industries."

Sandford J. Kilby, "Indian Salt Manufacture."

Cantor Lectures.

Monday afternoons, at 4.30 p.m.

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." Three Lectures.

Syllabus.

Lecture II.—March 17.—The carbonisation of coal and its relations to the domestic heating problem.

LECTURE III.—MARCH 24.—Coal conservation in relation to metallurgical industries and power production.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 17...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor W. A. Bone, "Coal and its Conservation." (Lecture II.)

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Dr. A. B. Rendle, "Bible Natural History."

Biochemical Society, Botany Building, Imperial College of Science and Technology, South Kensington, S.W., 5.30 p.m. 1. Mr. J. C. Drummond, "Observations on the Nature of the Fat-soluble Accessory Growth Promoting Substance." 2. Mr. S. B. Schryver, (a) "Demonstrations of New Laboratory Technique"; (b) "A Method for the Detection and Estimation of small amounts of Methyl Alcohol." 3. Miss Dorothy Haynes, "The value of Electrical Conductivity Measurements as a Criterion of Changes in Plant Saps."

Sanitary Engineers, Institute of, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. W. C. Easdale, "Sewage Disposal by dilution, including Chlorination of Sewage Effluent and Treatment of Sludge."

Geographical Society, Kensington-gore, W., 5 p.m. Colonel N. M. MacLeod, "Survey by Air Photographs."

TUESDAY, MARCH 18...Labour Co-Partnership Association, Kingsway Hall, Kingsway, W.C., 4.30 p.m. Mr. H. Bowden, "A Combination of Municipality and Co-Partnership—Poplar Electricity Department."

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS. John-street, Adelphi, W.C., 5.30 p.m. Messrs. M. A. Ockenden and A. Carter, "Plant Employed in the Percussion System of Drilling Oil Wells."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Professor G. Diouritch, "A Survey of the Development of the Serbian (Southern Slav) Race. An Economic and Statistical Study."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Scotland." (Lecture II.)

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. N. F. Horne, "Finishing Bromide Prints."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Mr. H. R A. Mallock, "Some Points in Insect Mechanics." 2. Mr. F. M. Duncan, "Exhibition of Photographs and Lantern-slides of Marine Zoology." 3. Mr. H. F. Blaauw, "On the Breeding of *Oryx gazella* at Gooilust."

Secretaries' Association, Winchester House, Old Broad-street, E.C., 7.15 p.m. Mr. J. Munford, "The Training of Women for Secretarial Careers."

WEDNESDAY, MARCH 19...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Sir Dugald Clerk, "The Distribution of Heat, Light, and Motive Power by Gas and Electricity."

Industrial Reconstruction Council, Saddlers' Hall, Cheapside, E.C., 4.30 p.m. The Right Hon. H. A. L. Fisher, "The Functions of Government in relation to Education."

Meteorological Society, at the Geological Society, Burlington House, W., 5 p.m. Dr. L. Hill, "Atmospheric Conditions which affect Health."

Microscopical Society, 20, Hanover-square, W., 8 p.m. 1. Dr. J. B. Gatenby, "An Account of Work on Cytoplasmic Inclusions of the Cell." 2. Lieut.-Colonel J. Clibborn, "A Standard Microscope." 3. Dr. N. Mutch, "A Simple Method for the Isolation of Single Bacteria for the Preparation of Pure Cultures."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Professor M. A. Gerothwohl, "Alfred de Musset."

THURSDAY, MARCH 20...Automobile Engineers, Institution of, at the Chamber of Commerce, New-street, Birmingham, 7.30 p.m. Mr. E. Caudwell, "The Engine of the Sidecar Motor-cycle."

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. F. Lewis, "Notes on a visit to Kunadiyaparawitta Mountain, Ceylon, with list of the plants observed and their altitudinal distribution." 2. Miss May Rathbone, "Specimens of Plants preserved by Formalin Vapour." 3. Mr. H. R. Amos, "Wheat-breeding with Mr. W. O. Backhouse in Argentina."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Mr. K. Truelove, "The Training of the School Girl in Infant Care."

Chemical Society, Burlington House, W., 8 p.m. Messrs. T. M. Lowry and H. H. Abram, "The Rotatory Dispersive Power of Organic Compounds. Part IX.—Simple Rotatory Dispersion in the Terpene Series."

Royal Institution, Albemarle-street, W., 3 p.m. Professor C. H. Lees, "Fire Cracks and the Forces producing them." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. G. Ardaseer, "Some Curiosities as seen by the Microscope."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 5.30 p.m. Discussion on the recent lectures on "Dielectrics in Electric Fields."

Britain and India, 7, Southampton-street, Holborn, W.C., 3 p.m. Dr. J. Oldfield, "From my Note Book on India."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. 1. Sir T. K. Rose, "The Volatilisation of Gold." 2. Mr. W. S. Curteis, "Cobar Stope Measurement Methods."

Japan Society, 20, Hanover-square, W., 4.30 p.m. Dr. W. L. Hildburgh, "Some Parallels between Minor Superstitions of Japan and Great Britain."

FRIDAY, MARCH 21...Poetry Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.15 p.m. Miss May Morris, "The Socialism of William Morris."

Royal Institution, Albemarle-street, W., 5.30 p.m. Professor W. W. Watts, "Fossil Landscapes."

Electrical Engineers, Institution of, and the Royal Society of Medicine (Electrical Section), (Joint Meeting), 1, Wimpole-street, W., 8 p.m. Mr. R. S. Whipple, (a) "Some Notes on Electrical Methods of Measuring Body Temperatures"; (b) "Some Notes on the Electro-Cardiograph."

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. H. C. Armitage, "Jigs, Tools, and Special Machines, with their Relation to the Production of Standardised Parts."

SATURDAY, MARCH 22...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Spectrum Analysis and its Application to Atomic Structure." (Lecture III.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—March 14, 1919.

No. 3461. MARCH 21, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C. 2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,461. VOL. LXVII.

FRIDAY, MARCH 21, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 24th, at 4.30 p.m. (Cantor Lecture.) WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Coal and its Conservation." (Lecture III.)

WEDNESDAY, MARCH 26th, at 4.30 p.m. (Ordinary Meeting.) ARNOLD HARTLEY GIBSON, D.Sc., M.I.Mech.E., Professor of Engineering, University College, Dundee, "British Engineering and Hydro-Electric Development. (The Training of Engineers.)" ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

Further arrangements were announced last week.

CANTOR LECTURE.

On Monday afternoon, March 17th, PROFESSOR W. A. BONE, F.R.S., delivered the second lecture of his course on "Coal and its Conservation."

The lectures will be published in the *Journal* during the summer recess.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 19th, 1919; The Right Hon. LORD MOULTON, G.B.E., K.C.B., LL.D., F.R.S., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Carlyle, Sir Robert Warrand, K.C.S.I., C.I.E., London.
Cochran, A., Calcutta, India.
Davies, Walter, M.B.E., London.
Dhunjeebhoy, J. S., London.
Hooker, William Alfred, London.
Kesterton, Henry Martin, A.M.I.A.E., Birmingham.
Paton, James Wallace, J.P., Birkdale, Lancashire.
Royce, Frederick Henry, West Wittering, Sussex.

The following candidates were balloted for and duly elected Fellows of the Society:—

Bhandari, J. G., M.A., Simla, India.
Doss, C. G. Narayana, Madras, India.
Garratt, Julius, Edgbaston.
Martineau, F. Leigh, M.I.Mech.E., M.I.A.E., London.
Owen, Captain Reginald Sankey, R.A.F., Stockport.
Roberts, John Edward, Alexandria, Egypt.
Robinson, Alfred E., Bombay, India.
Stevens, H. C. M., Wolverhampton.
Stubbs, Arthur, M.I.Mech.E., M.I.A.E., Smethwick.
Tekchand, Bakhshi, M.A., Lahore, India.
Wight-MacAdam, Robert, J.P., Dunbar, Scotland.

A paper on "The Distribution of Heat, Light, and Motive Power by Gas and Electricity" was read by SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Tuesday, March 4th, 1919; Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

THE CHAIRMAN said he scarcely thought it was necessary to introduce Professor McLennan, who was well known in the world of science. It might not, however, be known to all that Professor McLennan, although a Canadian by birth, was originally Scotch, both his father and mother being born in Scotland. He was educated in this country at Cambridge and returned to Canada, where he

became Professor of Physics at Toronto University. At the beginning of the war he once more returned to this country to assist the efforts that were being made for applying science to warfare, and was so successful in that respect that quite recently the Admiralty had offered him the post of Scientific Adviser to the Admiralty.

The paper read was—

SCIENCE AND INDUSTRY IN CANADA.

By Professor John Cunningham McLennan, O.B.E., Ph.D., F.R.S.,
Scientific Adviser to the Admiralty.

In dealing with the question of science and industry in Canada it is necessary to keep in mind that Canada is a comparatively new country. Though its area is of vast extent and covers more than half of the continent of North America, its population is as yet small, and does not exceed eight millions all told.

Though much has been accomplished, the greatness of Canada is even to-day mainly potential. It is the land of opportunity. Solid foundations have been laid in education, in agriculture, and in the matter of railway transportation, but only a beginning has been made in developing the mines and the fisheries, and in exploiting practically all the natural resources in industries. The water-powers of Canada, which in magnitude are second only to those of the United States of America, are being steadily developed. Capital has flowed and is flowing into the country. The war has given an immense impetus to industrial development, and the results which have been accomplished in the last four years in supplying war munitions, in increased production of foodstuffs of all kinds, and in increased output of manufactured products of every variety, have been equalled only by the magnificent military effort which has been put forth. All of these accomplishments have, I believe I am correct in saying, been far away and beyond all expectations which were held regarding the capabilities of Canada, by the most sanguine and the best-informed of her leaders.

In the short time at my disposal it will be my aim to refer briefly to a number of factors which have contributed, and will contribute with increased force in the near future, to accelerate the growth in power and wealth of this our fair Dominion.

I.—Education.

Education in Canada is under the control of the various Provincial Governments, the curricula and standards in any Province being fixed by the Education Department of that Province. Elementary education is free and is compulsory, except with some limitations in the Province of Quebec—school books being provided free in some cases—so that practically no Canadian children are handicapped by illiteracy. Secondary education is also practically free, or at most subject to low fees in all the Provinces, but not compulsory. About 25 per cent. of the child population takes advantage of this opportunity, attending what are called "high schools," or sometimes "collegiate institutes." These schools prepare students for the universities, the number matriculating and attending the latter being about 5 per cent. University education is also dealt with by each Province, which possesses a university situated either in the provincial capital or in some more important centre.

In addition, there are universities supported by private endowment as, *e.g.* McGill, at Montreal, or by a religious denomination as Queen's at Kingston, but nearly all are State-aided in some way or other. All give instruction in arts and sciences, pure and applied, in engineering, and some in medicine. Special mention might be made of forestry and agriculture. The larger universities are in affiliation with some of the universities of Great Britain, so that students may continue their work abroad if they desire.

It will be at once evident when the extent of Canada geographically is considered that the aims of the various universities differ somewhat —engineering, for example, occupying a large place in eastern universities while agriculture is emphasised in the west. In the Province of Quebec, where French is the language, tradition seems to incline the universities towards law and letters. Canada has some good medical colleges and dental schools, notably those attached to the universities of Toronto and McGill.

It may be mentioned in connection with war and the case of the Canadian Expeditionary troops, that no branch of the non-combatant forces has been more useful than the Canadian Dental Corps. It is generally admitted that in a large civilian army a deal of bad health and illness is traceable to defective teeth. The Canadian Army authorities have paid more attention to this point than has hitherto been the custom in Army administration in older countries, and with excellent results. The success of this branch of the Service is due to

the careful training given in the colleges of Canadian universities, one of the best of which is at Toronto.

It can also be said that the Canadian Medical Service has done excellent work. Canadian medical schools have been the training ground for this service, and Canada is proud to see among her sons a few at least whose names are well known abroad. Some of the hospitals are large and well-equipped. The Toronto General has a large bacteriological laboratory, and works in close co-operation with the anatomical, physiological, pathological, and biological laboratories of the university. The same can be said regarding the hospital associated with McGill University. At a little distance from Toronto, in the country, a serum station is now in operation under the administration of the University of Toronto. This institution, known as the Connaught and Anti-toxin Laboratory, has played a great part in the war by supplying practically the whole of the serum and anti-toxins used by the Canadian Army. It was founded through the munificence of Colonel Albert Gooderham, and is strongly supported financially by the Government of the Province of Ontario. The Director is Major J. C. Fitz-gerald, and the Assistant Director is Captain R. D. Defries. Among the biological products which have been prepared on a large scale in this laboratory are diphtheria anti-toxin, tetanus anti-toxin, anti-meningitis serum, smallpox vaccine, anti-pneumococcus serum, and a serum for the prevention of gas-gangrene infection of wounds. Its activities at present are being directed to the exploitation of curative methods for dealing with tuberculosis, influenza, and pneumonia, and in the scope of its researches it may be said, without exaggeration, to be comparable with the Lister Institute in England, the Pasteur Institute in France, and the Rockefeller Institute in New York.

In addition to the above, laboratories are provided at suitable centres for making analyses for the medical profession—in cases of diphtheria, typhoid, tuberculosis, rabies, etc., as well as analyses of water, milk, sewage, etc. The Western University, at London, also possesses a well-equipped and modern Institute of Public Health.

The higher education of *women* receives special attention in Canada, courses being provided in some universities, in addition to those leading to an arts degree, in home economics, household science, and agriculture. Several important endowments have been given of late years for this special purpose at Toronto, Guelph, and Ste. Anne de Bellevue.

The percentage of students who reach the universities in Canada is fairly high as compared with older countries; the reason being, in part, that for a person of small means there are opportunities in the vacation—which extends from June 1st to October 1st—of earning sufficient money to carry on with during the university terms. Some work on railways, some on steamers on the Great Lakes, some in the harvest fields in the east and west, and some in the forests.

Extension lectures are given by some universities, with a view to creating a wider interest in higher education. Members of the staff give lectures, where desired, on a great variety of subjects, chosen with a view to stimulating thought and activity. Macdonald College, at Ste. Anne de Bellevue, makes a special effort to reach the rural communities by offering free tuition in special courses.

Among other institutions worthy of special mention, are the School of Railway Engineering and the Forests Products Laboratory, attached to McGill University, Montreal. The former gives instruction in the location and construction of a rail line, of yards and terminals, as well as in the calculation of costs. It also deals with such matters as railway organisation, maintenance of way and materials, records and accounts. The latter is maintained by the Dominion Government, and it has performed, and is performing, a national service in exploiting the industrial utilisation of wood waste, pulp refuse, peat, straw, etc.

In the universities of Canada the activities of the staffs have been largely concentrated hitherto upon instruction. Research has been encouraged, but specific provision in staff and funds has not until recently been formally made for an elaborate research programme. Within the last few years, however, magnificently-equipped laboratories have been provided in the University of Toronto and in McGill University for research in physics, chemistry, mineralogy, biology, physiology, pathology, and engineering. Additions are being made to the staffs, and arrangements are being worked out for the *personnel* to devote time to research as well as to instruction. Scholarships and fellowships have been provided for research workers, and salaries have been so graded as to ensure a steady supply of the ablest investigators for filling the higher posts in each department.

II.—Agriculture.

Agriculture is the basic industry of Canada, and the greatest source of her wealth. The welfare and the prosperity of the Dominion depend on its development and its progress. The land in Canada capable of use for agriculture was estimated in 1914 to be 440,951,000 acres, and the amount under cultivation at present is given at about 110,000,000 acres, *i.e.* about 25 per cent. of the available supply.

There are about 120,000,000 acres of land capable of immediate cultivation. The following table gives the value of agricultural production in 1915, compared to other products :—

	$	Percentage of total.
Agriculture and Dairying	1,470,000,000	49
Forestry	177,000,000	6
Fisheries	33,000,000	1
Minerals	130,000,000	4
Manufactures	1,200,000,000	40
	3,010,000,000	

Both Dominion and Provincial Governments have recognised the importance of the improvement of agriculture, and there are probably more agencies for the education of the farmer in Canada than in any other State.

As already pointed out, agricultural colleges have been established in each Province, and are doing an increasingly valuable work in training the young farmer. Among them, Macdonald College at Ste. Anne de Bellevue near Montreal, affiliated to McGill University, and the Ontario Agricultural College at Guelph, which is affiliated with the University of Toronto, have become world renowned.

As early as 1886 the Dominion Government established an experimental farm in Ottawa, and four branch farms as well, one being in Nova Scotia, a second in Manitoba, a third in Saskatchewan, and a fourth in British Columbia. Their function was to assist the farmer by correspondence, and by demonstration with regard to the management of his land, the crops for which it was best adapted, questions regarding rotations, manures, fertilisers, the breeding, care, and feeding of live stock, the relative nutritive values of cattle foods and fodders, and the preparation and application of insecticides and fungicides.

The system has rapidly increased until to-day there are nineteen branch farms and experimental stations in existence. The two most recent stations, Spirit Lake, Quebec, and Kapuskasing, Ontario, have been cleared in densely wooded virgin land by interned aliens since 1914.

One of the most valuable investigations carried out by the Dominion Experimental Farms led to the production and introduction of a wheat that would ripen before there was the danger of early autumnal frosts. One of the very best varieties is the Marquis wheat. It has won the highest awards in international competitions open to the world, and has raised the annual value of the Canadian wheat production by many millions of dollars.

Varieties of oats capable of withstanding the severe climatic conditions of the north-western portion of Canada have also been developed.

In 1915 the army cut-worm appeared in destructive numbers in Alberta. Where the grain crops in an area of 3,000 square miles were threatened, means of controlling the spread of this pest were immediately and successfully investigated, and extensive damage was prevented, thus saving the loss of many hundreds of thousands of dollars.

Many problems yet remain for solution, one of the chief of these being the production of a rust-proof wheat. In 1916 great damage was caused by grain rust in Southern Manitoba and Southern Saskatchewan, and investigation has already been commenced on this subject at field laboratories in the west. In the Agricultural College of Manitoba a rather important discovery has been made recently by the professor of biology, in associating this wheat rust with a very common western weed as its winter host.

Another problem awaiting solution is the economic utilisation of the straw produced in the Western Provinces. A process which will turn this otherwise waste product into a useful material will result in the gain of many millions of dollars. In the three Prairie Provinces about 20,000,000 acres are under crop, and assuming that there is one ton of straw per acre, which is a conservative estimate, about 20,000,000 tons of straw would be available per year. Some experiments have recently been made on the gas-producing qualities of this by-product of agriculture, and it has been found that one ton of straw yields about 11,000 cubic feet of gas. This, when purified, yields about 10,000 cubic feet of fuel gas, with a thermal value of 400 B.Th.U. Assuming that about 30 per cent. of the gas obtained is required to carbonise a ton of straw, then from every ton there would be a supply of about 7,000 cubic feet. From 20,000,000 tons of straw at 7,000 cubic feet of gas per ton, and 400 B.Th.U.'s per cubic foot, there would be available for fuel purposes an

energy equivalent of about 2,511,000 horse-power years. From every ton of straw there is also obtained from 6 to 8 gallons of tar and ammoniacal liquors and about 600 lb. of carbon residue. This will suffice to show that the straw problem in Canada is worth paying attention to. At the present time wheat and flax straw is entirely wasted. Oat straw is used to a small extent where mixed farming is practised. If straw can be utilised as a fuel in the form of gas, the fuel problem for the farmer will be solved, as he will then be able to produce a supply for his own purposes.

Up to the present, Canadian farmers have had little need of fertilisers; but the time will soon come when they will be required in large quantities. This demand will be easily met if the water-powers are utilised to manufacture synthetic nitrates, and an economic process is found to separate potassium in suitable form from the great stores of feldspar Canada possesses. Phosphate deposits exist in the country, but special methods of treatment must be worked out before a fertilising agent of this variety is available.

III.—The Mineral Wealth of Canada.

Nickel.

About 80 per cent. of the world's supply of nickel—42,400 short tons—is mined in the Sudbury region of Ontario by three companies—one American, the International Nickel Co.; one English, the Mond Nickel Co.: and a newly-established company, the British-American Nickel Corporation.

The ores are sulphides, including pyrrhotite, pentlandite, and chalcopyrite, the pentlandite containing the nickel. The ores are roasted in heaps to drive off sulphur, and are then smelted in water-jacketed furnaces to a standard matte containing 25 to 30 per cent. of nickel and copper. This is further smelted in basic converters to Bessemer matte containing 75 to 80 per cent. of the metals.

Each company employs its own process for the final separation of the metals; the International Nickel Co., by several smeltings with alkali sulphates; the Mond Co., by the aid of carbon monoxide which forms a volatile compound with nickel from which the metal is afterwards separated; and the British-American Corporation by an electrolytic process.

One problem to be solved in the metallurgy of nickel is an economic method of utilising the sulphur dioxide which is at present turned into the air. As much as 1,000 tons a day escape from the waste beds, destroying vegetation for miles around. Iron also is lost in the smelting processes. In the sulphur dioxide we have a source of enormous supplies of sulphuric acid, but the problem of producing it economically has yet to be satisfactorily solved.

Copper.

The total production of copper in 1917 was estimated to be 56,500 short tons, about 3·5 per cent. of the world's supply. It is mainly recovered from the metal-copper ores of the Sudbury region. Until last year no copper was refined in Canada, but the International Nickel Co., and the British-American Nickel Corporation have recently installed refineries in Ontario.

Zinc.

An electrolytic zinc refinery has lately been put in operation by the Consolidated Mining and Smelting Co., of Canada, at Trail, B.C., resulting in the production of 10,250 short tons of zinc. As the total zinc production for 1917 was estimated at 15,500 short tons—approximating to $14,000,000 in value, it will be seen that about 70 per cent. of the Canadian ore is now refined in Canada.

Gold.

Canada produces about 3·6 per cent. of the world's supply of gold. The value of the metal refined in Canada in 1916 was $19,234,976 in value and 930,492 fine ounces in amount.

Some 25·8 per cent. of the total was obtained from alluvial workings, 54·5 per cent. from the crushing of quartz ores and 19·7 per cent. recovered from ores and concentrates sent to copper and lead smelters.

Chrome Ore.

Several of the metals so urgently required for the manufacture of special steels for munition purposes have been supplied by Canada since the war. Canada is one of the principal sources of supply of chrome ore, and the production for 1917 was 23,327 tons valued at $572,115. Investigation has shown that large supplies of low-grade ore found in Quebec can be successfully concentrated, and it is hoped that electric furnaces may be erected in that Province for the production of ferro chrome.

Molybdenum.

Before the war Canada produced practically no molybdenum. On account of the demand in 1915 successful prospecting was carried out, and through a method of concentration developed by the Canadian Mines Branch, the supply rapidly grew. The production increased from seven tons of molybdenum concentrates in 1915

to 140 tons in 1917, forming a considerable percentage of the world's supply.

Magnesite.

Formerly practically all the magnesite used in the United States and Canada for lining open hearth and high temperature electric steel furnaces was supplied from Greece and Austria. The war caused the cessation of this supply, and after successful prospecting production in Canada rapidly developed. It was always supposed that the Canadian mineral was inferior to the European, but it has been demonstrated that with proper treatment it produces an efficient refractory comparable to the Austrian product. The Canadian production increased from 120 tons, valued at $840 in 1908, to 58,000 tons, worth $593,000, in 1917, a rise in value of 70,000 per cent.

The Mines Branch, Department of Mines.

The satisfactory position of the Canadian mineral production is in no small measure due to the highly efficient Mines Branch of the Department of Mines under the directorship of Dr. Eugene Haanel.

The function of the department is to assist the development of the mineral resources of the country, and it carries out its work by the production of statistics and reports, and by scientific and economic investigations. The department has grown rapidly, and to-day comprises a chemical division, metal and non-metallic divisions, statistical division, fuel-testing station, ore-dressing and metallurgical laboratories, metallographic laboratories, ceramic laboratories, structural materials laboratory, and a road materials laboratory, besides the necessary clerical staff, library editorial division, and workshops.

Among the outstanding investigations that have been carried out are the electric smelting of iron ores, the production of metallic cobalt, and its use in electro-plating, the examination of Canadian coals, the analysis of mine air, the utilisation of peat, the concentration of molybdenite, and the investigation of the available supply of building stones.

No less than 470 reports and bulletins have been published since the establishment of the Mines Branch in 1907, many of them of great scientific and economic value.

IV.—Coal Resources of Canada.

The fuel resources of Canada are diverse in character and enormous in extent. If one considers coal alone, Canada's coal reserves take second place in the rank of the estimated reserves of the various countries of the world, the United States reserves being the greatest.

This being the case, there would seem to be no justification for the fact that some 50 per cent. of the annual coal consumption in the Dominion is imported from the United States. This arises from the geographical location of the coalfields at present worked; the production being in the extreme east and in the extreme west, in the proportions (taking 1916 figures) of—

Nova Scotia . . .	about	50	per cent.
Alberta	„	30	„
British Columbia .	„	18	„
Saskatchewan . .	„	2	„

of the yearly consumption.

It will be seen from the above that the Provinces of Ontario and Quebec, with their large populations and their extensive industries, are largely dependent upon the United States for their coal supply. This is also true of Manitoba and Saskatchewan. The Western Provinces, however, have many million tons of fuel available, but it is estimated that about 90 per cent. is lignite or of the sub-bituminous variety.

This lignite was recently the subject of a report by the Honorary Advisory Council for Scientific and Industrial Research, which devoted itself to the problem of fuel at the commencement of its activities.

This report recommends the production of a fuel suitable for domestic use from the lignites of Saskatchewan.

The method of manufacture projected is:—

1. Carbonisation of the lignite by which the moisture (some 40 per cent.) is driven off.
2. Briquetting, under pressure, of the carbonised residue, using a binder, such as sulphite pitch—a waste product from pulp-mills.
3. Waterproofing of the briquettes by heating, which is intended to coke the binder.

The estimated cost per ton of briquettes at the mine is $7·00, which is $3 to $5 less per ton than Pennsylvania anthracite at the same place. The value of by-products such as gas, ammonium sulphate and tar is neglected in this estimate. The net result of the process will be, that from two tons of lignite approximately one ton of briquettes with a calorific value of anthracite will be obtained. The Council recommended the expenditure of $400,000 on a plant, with a capacity of some 30,000 tons of briquettes per year.

As a consequence of this report, the Dominion Government, by an Order in Council, created the Lignite Utilisation Board of Canada, which is financed by the Dominion Government and by the Provincial Governments of Manitoba and Saskatchewan.

The Board is at present investigating operating plants, machinery, and processes in the United States and in Canada, and it is expected that the Canadian plant will be in operation in the spring of 1920.

If this experiment is successful with Saskatchewan lignite, the other higher grade fuels will also be utilisable, and by public or private development along the lines proved to be the best, the Canadian Middle West should become independent of other fuel supplies.

Interlinked with the question of coal supply, and the development of coal resources, is that of hydro-electric energy.

In certain areas in Canada where the coal resources are small, the water-power available is extensive and can be used to release coal for heating purposes. It can be shown (it is a question of relative efficiencies) that, within the limits of practicability, fuel should be used for heating, *e.g.* houses and hydro-electric energy for mechanical power.

Recent figures (1916) show that about one-third of the total coal consumption in Canada is used by locomotives. Development of hydro-electric power, and the electrification of railroads, where possible, will be a step in the right direction, and will release coal for heating purposes, and vast numbers of railroad trucks for transportation.

The use of hydro-electric energy on an *extensive scale* for heating cannot be looked to as a solution of a coal supply, either from the point of view of general considerations such as the seasonal load, or from the point of view of relative efficiencies. But as an auxiliary in such cases as electric furnaces, welding, cooking and heating on a small scale, it will help to ease the situation and release coal for more efficient use. It will be pointed out later, that the best policy to pursue will be to develop, as rapidly as possible, all the hydro-electric powers available in Manitoba, Ontario, and Quebec, to use the electric energy as far as it is required in these Provinces for mechanical power, in industrial works, and for electrifying the railroads, and to hold the balance as a means of barter with the United States, in order to obtain from that country the coal required for heating purposes by the Provinces mentioned.

V.—Honorary Advisory Council on Scientific and Industrial Research.

On June 6th, 1916, there was constituted by Order in Council, a Sub-Committee of the Privy Council, consisting of the Right Honourable Sir George E. Foster, G.C.M.G., Minister of Trade and Commerce (Chairman), the Honourable the Ministers of the Interior, Agriculture, Mines, Inland Revenue and Labour, with the object of having charge of all measures to foster the scientific development of the industries of Canada, in order that during and after the present war these may be in a position to supply all Canadian needs and extend Canadian trade abroad.

Under this Sub-Committee of the Privy Council, and by its direction, an Honorary Advisory Council for Scientific and Industrial Research was constituted on November 29th of the same year, composed of eleven representatives of the scientific, technical and industrial interests of Canada.

This Advisory Council, by the direction of the Chairman of the Sub-Committee of the Privy Council, was charged with the following duties :—

(*a*) To ascertain and tabulate the various agencies in Canada which are now carrying on scientific and industrial research in the universities and colleges, in the various laboratories of the Government, in business organisations and industries, in scientific associations, or by private or associated investigators.

(*b*) To note and schedule the lines of research or investigation that are being pursued by each such agency, their facilities and equipment therefor, the possibilities of extension, and, particularly, to ascertain the scientific man-power available for research, and the necessity of adding thereto.

(*c*) To co-ordinate these agencies so as to prevent overlapping of effort, to induce co-operation and team work, and to bring up a community of interest, knowledge and mutual helpfulness between each other.

(*d*) To make themselves acquainted with the problems of a technical and scientific nature that are met with by our productive and industrial interests, and to bring them into contact with the proper research agencies for solving these problems, and thus link up the resources of science with the labour and capital employed in production, so as to bring about the best possible economic results.

(*e*) To make a scientific study of our common unused resources, the waste and by-products

of our farms, forests, fisheries, and industries, with a view to their utilisation in new subsidiary processes of manufacture, and thus contributing to the wealth and employment of our people.

(f) To study the ways and means by which the present small number of competent and trained research men can be added to from the students and graduates of science in our universities and colleges, and to bring about in the common interest a more complete co-operation between the industrial and productive interests of the country and the teaching centres and forces of science and research.

(g) To inform and stimulate the public mind in regard to the importance and utility of applying the results of scientific and industrial research to the process of production by means of addresses to business and industrial bodies, by the publication of bulletins and monographs, and such other methods as may seem advisable.

The Advisory Committee of British Columbia.

Though the Council was not constituted with the view of representing territorially the different parts of the Dominion, its membership includes residents of all parts of Canada except the extreme West. The difficulties that distance imposes determined this exception. The Council, to meet the situation, has constituted an Advisory Committee for British Columbia. This Committee, consisting of fifteen members and representing the University of British Columbia and the joint technical organisation of the Province, will constantly keep under survey the industries of the Province and report its recommendations as they are agreed upon to the Council for action thereon.

Associate Committees.

In order that the Council may have the assistance of the best expert advice along a number of technical lines, it has appointed several committees composed of a number of leading specialists to whom may be referred, as the occasions require, questions and problems in the solution of which the wide experience and technical knowledge of each such committee may be of very great service. Three of these are permanent organisations—the Associate Chemical Committee, the Associate Committee on Mining and Metallurgy, and the Associate Committee on Forestry. It has been arranged that the chairman of each shall be a member of the Council, in order that its work may be in intimate relation to that of the latter. It is contemplated that other such committees will be appointed as the need for them develops.

Assisted Researches.

Since it was constituted the Council has followed the policy of making from time to time financial grants in aid of researches which appear promising. Among those which have been supported and appear to be of immediate practical importance are:—

1. The investigation of tar fog. The results of this investigation, which involves the use of the Cottrell precipitation process can be and doubtless will be applied to plants in Canada engaged in the destructive distillation of coal, wood, the liquid products resulting from the manufacture of producer gas, etc.

2. The utilisation of waste straw for the production of gas for heating and lighting farmhouses.

3. An investigation regarding the transmission of sound with a view to improving the methods of fog signalling on the St. Lawrence and the other navigable waters of the Dominion.

4. A study of Canadian waste tobacco, with a view to preparing nicotine sulphate for use as an insecticide for certain shrubs and fruit trees.

5. The determination of vapours and gases directed towards devising a method for ascertaining the amount of benzine and toluene vapours found in gases such as coal gas products of the distillation of wood, etc.

6. The investigation of the possibility of using the tar sands of Alberta for the construction of pavements similar to those now made from asphalt.

7. Experiments on the application of the principle of flotation to new economic ores found in Canada.

8. Investigation of the amount and character of the sugars in the silphite liquor waste from pulp works.

9. Investigation of the genetics of wheat with a view to producing an early maturing variety which is rust-resisting.

10. Investigation of the reduction of low-grade ores by means of gas at a comparatively low temperature. These ores abound in Canada, and it is hoped that the method of treatment indicated can be worked out so that final fusion and reduction can be successfully carried out in small electrical smelters at a number of localities in the country.

11. The carbonisation and briquetting of the lignites of Saskatchewan, details of which have already been referred to in dealing with the

fuel question. Other problems which are being examined are—(1) The production of potassium salts from feldspar; (2) fish waste; (3) industrial alcohol from wood waste; (4) industrial alcohol from sulphite liquor waste; (5) the utilisation of scrap leather; and (6) the production of toluene from the turpentine and cymene present in the sulphite liquor waste, from the pulp mills.

With a country like Canada rich in natural resources, hundreds of problems await solution, and the main difficulty the Council experiences at present is in devising effective measures to deal with them adequately, having in mind that the supply of scientific workers is small, the available laboratory accommodation limited, and the financial support afforded to date not by any means extravagant.

Studentships and Fellowships.

To increase the number of investigators in science who may be induced to follow a career as such in connection with the Canadian industries, the Council established twenty-five studentships and fellowships to be awarded to young graduates of our universities and technical colleges, who have given evidence of the possession of the special knowledge and capacity required for the conduct on their part of independent research in some department of science which bears on industrial processes. Owing to the depletion of the student ranks in our universities, which has been going on for the last three years, the number of such graduates has been very small, and, in consequence, only seven were found qualified for appointment, three to fellowships and four to studentships, all of whom are now engaged in research, each on a different problem, under the supervision of the professor or director of a laboratory in one of four different universities. The Council has hopes of increasing the number of appointees for the coming year.

Research Institute.

The Council has had under consideration for some time the question of the organisations which should be created and the methods to be adopted, by the aid of which Canadian industries may be assisted to develop by the application to them of the most advanced scientific processes, and thereby enabled not only to meet the needs of the home markets, but also to compete with their rivals abroad.

To meet this situation the Council has drawn up a Bill for presentation to Parliament, providing for the establishment at Ottawa of a Research Institute having the functions of the Bureau of Standards at Washington or of the National Physical Laboratory of Great Britain. Attached to the Institute, it is suggested there should be laboratories that may be at the disposal of guilds or associations for research, which may be founded by the various Canadian industries, each in its own line, the firms or companies of which are unable individually to undertake experimental investigations with the object of improving their manufacturing processes. It is expected that the necessary legislation for establishing this Institute will be passed during the present Parliamentary session.

VI.—Canadian Water-powers.

In dealing with the question of water-powers in Canada, I cannot do better than refer you to the reports recently prepared by the Water Powers Committee of the Conjoint Board of Scientific Societies. In these reports it is pointed out that the organisations existing for the collection of information on water resources and their development in Canada, are both Federal and Provincial.

1. *Federal Organisations.*

The most important of the federal organisations which contribute to this end are:—(1) The Dominion Water Power Branch and the Irrigation Branch of the Department of the Interior; and (2) the Commission of Conservation of Canada.

The Dominion Water Power Branch.—(i) This organisation carries out in New Brunswick and Nova Scotia all stream measurement work, and power and storage investigations, co-operating with the New Brunswick and the Nova Scotia Water Power Commissions in their respective Provinces; (ii) does similar work in Manitoba as "The Manitoba Hydrometric Survey"; (iii) carries out power and storage investigations in Alberta and Saskatchewan, co-operating with the Irrigation Branch of the Department of the Interior, which is responsible for stream measurement work in these Provinces; (iv) carries out stream measurement work in British Columbia as "The British Columbia Hydrometric Survey," co-operating with the British Columbia Water Rights Branch.

The Dominion Water Power Branch also works in conjunction with the Department of Trade and Commerce in statistical compilation, *e.g.* in taking a census of electrical central stations and hydro-electric undertakings throughout the Dominion.

Investigations which touch on international and navigable waters are directed by the Public Works Departments, while meteorological data are supplied by the Meteorological Service for Canada, which is maintained by the Department of Marine and Fisheries.

2. *Provincial Organisations.*

The most important of the Provincial organisations are:—

(i) The Hydro-electric Power Commission of Ontario;

(ii) The Quebec Streams Commission;

(iii) The New Brunswick and Nova Scotia Water Power Commissions; and,

(iv) The British Columbia Water Rights Branch.

The Provinces of Manitoba, Saskatchewan, and Alberta are distinct in that water-power investigations and administration are under federal control.

3. *Summary of Hydro-electric Powers Developed.*

The total estimated water-powers of Canada aggregate some 18,800,000 h.p., divided approximately as follows:—

	Per cent.	H.P.
Ontario	31	5,800,000
Quebec	32	6,000,000
Manitoba, Saskatchewan, Alberta and North-West Territories	18	3,500,000
British Columbia	16	3,000,000
Remainder of Dominion	3	500,000

Of the available power in the various portions of the Dominion, the following percentages, approximately, have been developed:—

	Per cent.
Ontario	13
Quebec	9·5
British Columbia	7·0
Remainder of Dominion	2·5

The total development is about 10 per cent. to 12 per cent. of the whole available supply, amounting to some 2,310,000 h.p., of which quantity slightly under 10 per cent. is exported to the United States. Some notable developments in the country are as follows:—

Quebec—

	H.P.
Shawinigan Falls	200,000
Grand Mers Falls	125,000
Gres Falls	75,000 (under construction)
Cedar Rapids	120,000 (final, 180,000)
Chambly	20,000
Lachine	13,000
Soulanges Canal	13,000
St. Timothee	20,000 (final 50,000)
Seven Falls	15,000 (under construction)

Several smaller plants are in operation, some of them on power sites capable of immense development.

Ontario—

	H.P.
Chaudiere Falls	36,000
Lake Huron Tributaries	56,000
Lake Superior	20,000
Rainy River District	22,000
Niagara Falls—	
Canadian Niagara Power Company	100,000
Toronto Power Company	125,000
Ontario Power Company	210,000

The Ontario Power Company is now owned and operated by the Hydro-Electric Power Commission of Ontario.

In Manitoba, the Winnipeg Municipal Plant and the Winnipeg Electric Railway Company's plant are capable of generating 80,000 h.p. In British Columbia there are several large developments as follows:—

	H.P.
Kootenay and Kettle River	23,000
Lake Buntzen	84,500
Stave Lake	26,000 (26,000 being added)
Jordan River, Vancouver Island	25,000
Powell River	24,000

4. *The Hydro-Electric Power Commission of Ontario.*

The Hydro-Electric Power Commission of Ontario owns and operates the following systems, in addition to the Niagara System:—

	H.P.
Port Arthur (purchased power)	20,000
Nipissing	3,400
Muskoka	1,500
Wasdell's Falls	1,100
Severn	3,000
Eugenia	4,000
Central Ontario System	22,600
St. Lawrence System (purchased power)	500
Rideau System (being constructed)	1,500
Ottawa System	10,000

In connection with the Port Arthur system, the Commission has commenced work on a new development on the Nipigon River, which will have an ultimate development of from 50,000 to 75,000 h.p., under a 60-ft. head, and there are three other sites which can give a further 100,000 h.p. when required. Power will be transmitted at 110,000 volts to the cities of Port Arthur and Fort William at the western end of Lake Superior. The drainage area of the district is 9,100 square miles.

Sites in the Central Ontario District, along the Trent Valley Canal, are available, whence about 75,000 h.p. can be obtained; and plans for the

development of 10,000 h.p. of this amount under a head of 46 ft. at Ranney's Falls are now being prepared, and construction will be commenced in the near future. At High Falls in the Rideau District about 2,500 h.p. is being developed under an 80-ft. head.

In Ontario there are several water-powers of considerable size, which, owing to the smallness of the population in the surrounding district, cannot be economically developed, unless the intended establishment of some electro-chemical or electro-metallurgical industry requiring a large amount of power should make this possible. In such a case the population within transmission distances would immediately benefit, and would certainly tend to increase, owing to the improved conditions consequent upon the availability of electric energy, light, power, and transportation. A specific case is that of Chats Falls on the Ottawa River, where, at a distance of about thirty miles west of the city of Ottawa, about 70,000 h.p. is available for development under a head of about 40 ft.

It is worth noting that in Canada practically every city and town of importance is within transmission distance of hydro-electric energy, and statistics show that the developed power in the country now amounts to about 200 h.p. per thousand of the population of the cities of the Dominion.

Altogether the Hydro-Electric Commission of Ontario has power under development, and in contemplation, as follows:—

Development.	Present H.P.	Ultimate H.P.
Chippewa	300,000	1,000,000
Nipigon	50,000 to 75,000	130,000
Rideau	10,000	10,000
Trent	10,000	75,000
St. Lawrence	—	750,000
Ottawa	—	60,000
Severn, Wasdell's, Eugenia and Muskoka	6,000	25,000
	376,000	2,050,000

At Niagara the Commission commenced work in 1917 on what is known as the Queenston-Chippewa Development; this involves the construction of a canal about 12¾ miles long, run from the point above the Falls where the Welland River runs into the Niagara River down to a location near Queenston, where the power-station will be erected. Existing power companies at Niagara utilise the drop at the Falls, and obtain about 150-ft. head; but between the foot of the Falls and Queenston there is a further drop of about the same amount.

The object of building this canal is to utilise all the head available. Actually, in this particular scheme, the net head utilised will be 305 ft., so that from the same quantity of water there will be generated in the new plant about twice as much power as is at present being obtained from the existing plant at the Falls.

The Commission has purchased land enough to allow of two more canals being built, and by means of these three it will be possible to generate 1,000,000 h.p. at the Queenston site.

The canal now under construction will enable 300,000 h.p. to be developed, and the initial plant will consist of four 50,000 h.p. turbines and generators, thus giving 200,000 h.p., while it will be possible later to instal a plant of another 100,000 h.p. capacity.

As indicating the rapid growth of the operations of the Hydro-Electric Commission of Ontario, it may be mentioned that in 1910, when current was first supplied, about 750 h.p. was furnished to a few municipalities this winter; only eight years later, 225 municipalities are taking over 200,000 h.p. The capital investments under the control of the Commission will, by the year 1921, be about $110,000,000.

The war taxed the Commission's energies very heavily, as the demands for power were extremely insistent, and, in the aggregate, enormous.

The following tabulation shows the power demand, with approximate output, of some of the munition firms taking electric power in the Niagara district:—

Approximate H.P.	Product.	Approximate output in tons.
14,600	Ferro-silicon; electrodes for electric furnaces	3,300 per month
25,500	Chemicals for explosives	Total not available
8,000 (day) to 40,000 (night)	Carbide of calcium	64,000 per annum
1,000	Grain sacks, lint, etc.	5 per day
2,500	Castings, car couplers, etc.	773 per month
	Bars, etc.	3,440 per month
3,000	Beaver board	18,000 per annum
450	Iron pipe	200 per day
2,900 to 9,000 (approximate peak).	Wood pulp and news print paper	50,000 per annum

The rates for power charged by the Commission to the various municipalities range from about \$70·00 to \$11·50 per h.p. year. The rates for power, lighting, etc., charged by the municipalities to their customers, are under the control of the Commission, and they are based on the fundamental principle that power can be supplied at cost.

The value of the Commission's work may be gauged to some extent by the fact that, were the 200,000 h.p. at present being supplied generated from coal, even in fairly large efficient central stations, some 2,000,000 tons, costing about \$10,000,000 would be required annually, and since Ontario has no coal, all this money would go out of the Province, mainly to the United States.

The approximate capacity of the Commission's largest transforming station is 220,000 h.p., and up to October 31st, 1917, the total capacity of transformers installed, or on order, for transforming and distributing stations was over half a million horse-power.

The total route miles of 110,000 volt transmission lines number more than 430, the circuit miles being above 670. The total length of low tension and distribution lines completed to September 29th, 1918, are as follows:—

Voltage.	Route miles of line.
44,000	184
26,400	481
22,000	415
13,200	401
6,600	19
4,000	233
2,200	20
Total	1,753

The foregoing figures are exclusive of a considerable mileage of 2,200 volt rural lines, and also of all the local distribution lines within cities and towns, the total mileage of which must be very considerable.

About 5,000 hamlet and farm consumers are being supplied with electric energy, the contracts with the latter being practically all for 2 h.p. each, and at times, when the farmers require more power, they pool their contracts, so that each farmer of a group of ten or twelve can, in turn, use a maximum of 20 h.p. or so for several days, while the rest use little or no power during this period. Then another farmer takes his turn, and so on.

Applications for power for farms are being received from almost all over the Province.

A group of farmers, such as that referred to, purchases a 25 h.p. motor, which is mounted on a truck with necessary transformers, switches, etc., so that the entire equipment can be moved from place to place. The work done by the farmers, under their 2 h.p. and combined 20 h.p. or so contracts, includes milking, pulping roots, chopping, pumping of water, separating of cream, threshing, ensilage cutting, grain chopping, etc., and in addition the farmers' wives get the benefit of electric light, fans, smoothing irons, vacuum cleaners, heaters, and even cooking stoves. The districts served are of three distinct types—dairying, stock feeding, and fruit growing sections. The rural lines serving such districts are also steadily picking up other loads for manufacturing purposes, such as brick and tile yards, gravel plants, quarries, stone-crushing plants, etc.

In addition to its other departments, the Commission also maintains an efficient laboratory which makes electrical, physical, and mechanical tests on transformers, instruments, meters, lamps, wire, cement, concrete, paint, oil, etc., as may be required, as well as a large purchasing department, which buys immense quantities of electrical and other materials in bulk, for sale to the municipalities at cost.

5. *Boundary Waters.*

In dealing with the development of boundary waters in Canada, it may be pointed out that the St. Lawrence River may be classified as follows (the figures being approximate only):—

WATER POWERS OF THE ST. LAWRENCE RIVER.

Site.	Head available.	Estimated low-water 24-hour H.P.	Average estimated 24-hour low-water H.P.
Morrisburg Rapide Plat	11–30	200,000 — 500,000	500,000
Long Sault Rapids	30–50	500,000—1,000,000	1,000,000
*Coteau Rapids	15–17	230,000 — 260,000	250,000
*Cedar Rapids	30–32	490,000 — 525,000	500,000
*Split Rock and Cascade	14–18	220,000 — 280,000	250,000
*Lachine Rapids	20–30	300,000 — 450,000	375,000
	Total	1,940,000—3,015,000	2,875,000

All the figures in the lines marked * were taken from a pamphlet of St. Lawrence River Water Powers, published by the Commission of Conservation, in which the following statement occurs:—

"To summarise, we may place the estimated low water power of the international portion of the River St. Lawrence at about 800,000 h.p., of which Canada is entitled to 400,000 h.p."

The development of hydro-electric power in international boundary waters, and in the vicinity of the international boundary line, is of vital interest to Canada, and has a direct bearing on the question of *coal shortage*, which has been recently acute.

That portion of Canada which is rich in hydro-electric possibilities under international control is precisely that portion which is, at present, dependent upon the United States for its coal supply.

It is within the possibilities that the time may come when the United States may desire to reserve her coal supply for her own purposes, for United States scientists and publicists are very much alive to the policy of the retention of essential commodities for a country's own use. The Director of the United States Geological Survey, for instance, commenting on the *world's coal supply*, remarks:—

"A glance at the world's reserve of coal shows plainly not only that the United States leads all other countries in production—our annual output being 40 per cent. of the total—but also that it possesses the greatest reserves. Yet in respect to no mineral is there greater need to emphasise the folly of exporting the raw material. Let us keep our coal at home, and with it manufacture whatever the world needs."

This point of view, quite natural and logical, indicates the attitude that Canada might adopt in the export of hydro-electric power.

Under the existing legislation, the Federal Government issues licences *for the exportation of electricity to the United States*, and at the present time Canada exports electric energy from New Brunswick to the State of Maine, from Quebec to New York State, from Ontario to New York State and Minnesota, from British Columbia to the State of Washington.

Recently, to quote a case in point, the Cedar Rapids Manufacturing and Power Company developed a portion of an ultimate installation of 180,000 h.p. on the St. Lawrence River, and the power generated—some 65,000 h.p.—is transmitted to the Aluminium Company of America, Massena, New York State.

If we consider the situation at Niagara—I quote 1917 figures—we have about 388,500 h.p. generated on the Canadian side, and 265,000 h.p. on the American side, and the exportation to the United States from Canada is about 125,000 h.p.

During the war the power shortage in the south-western part of Ontario was very marked. This was partly due to the industrial activity in munition plants, in electro-chemical industries, and in other war manufactories. Municipalities were called upon to exercise the strictest economy so as to reduce the peak load, and they responded to this request loyally.

It is evident from the above that the question of the exportation of power from Canada calls for some consideration, and demands the adoption of some policy that will avoid friction. The chairman of the Hydro-Electric Power Commission has been urging the retention in Canada of sufficient power to meet the present call. But, on the other hand, it is apparent that, if great industries are built up in the United States relying on the use of imported Canadian power, a ruthless ban on exportation of power from Canada might lead to complications of the gravest nature. On the other hand, from Canada's standpoint, it would seem reasonable that she should assure herself of an equivalent import of coal before entering upon agreements for export of electric energy.

It would seem a fair policy to arrange for equal quantities of power to be used on each side of the line (where the power available is international), and on that basis, combined with existing international agreements, export of power at Niagara could be reduced by about 63,000 h.p. (1917 figures). If this were done, and the Queenston-Chippewa development completed, the power shortage in the Canadian Niagara district would be greatly alleviated. It must not be thought, from the preceding remarks, that the official relations between Canada and the United States in regard to these questions, have been anything but felicitous. In the recent coal shortage, Canada has received generous treatment from the United States, portions of which are in as serious a position from lack of fuel as Canada itself. But it should be emphasised as fundamental that Canada should conserve, for purposes of exchange for her vital needs, such resources as hydro-electric power and others, such as pulpwood, asbestos and nickel, in which she has the good fortune to be particularly rich. This is the policy strongly advocated by the Commission of Conservation of Canada.

6. *Distribution of Canadian Water-powers.*

Before leaving the subject of water-powers, I desire to call your attention to the map before you, which shows, at a glance, the magnitude and distribution of the developed and undeveloped but measured water-powers of Canada. The red areas represent to scale the developed powers, and the green areas the undeveloped ones. In the Montreal district, for example, there is a larger development at the present time than exists at Niagara on the Canadian side of the river. Within eighty miles of Winnipeg an equal amount of power is available. Within a few miles of Vancouver 750,000 h.p. can be easily developed. On the St. Maurice River, which includes powers at Grand Mere, Le Gres Falls, La Tuque Falls, and Shawinigan, some 500,000 h.p. has been developed, and of this 100,000 h.p. is now available for new plants. On the upper reaches of the St. Maurice, at La Loutre, a large storage reservoir is being constructed, which will form a lake 360 square miles in area, and will impound sufficient water to generate 1,000,000,000 kw.h. in power. When this scheme is completed, and the powers developed on waters subsidiary to the St. Maurice, the total power immediately in sight in this district totals up to 1,091,000 h.p.

On the Saguenay River there is one of the best power sites in North America—Lake Saint John, which is the source of the river, and is about 100 miles north-east of the city of Quebec. The area of the lake is about 350 square miles, and its elevation above sea-level is about 315 ft. The drainage area of the lake is approximately 30,000 square miles. Three power sites, which can be easily developed on the Saguenay, are capable of producing a total of 1,000,000 h.p. at tide water. Deep-water basins are available, and numerous sites for docks and industrial plants are close at hand, so that industrial products can be loaded immediately on ocean-going vessels of the largest type without the necessity of any intermediate transportation by rail.

VII.—Electro-chemical and Other Industries.

In closing this paper, I cannot do better than call your attention briefly to some of the technical and industrial consequences of the development of hydro-electric power in Canada.

In general, when a power has been developed in the past, the supply of energy rendered available was far in excess of the requirements of the local community for light and mechanical power in manufacturing industries. This state of affairs led to the erection of extensive and important electro-chemical works which need large blocks of cheap power to meet their technical requirements. Examples of this development are found in the Niagara peninsula, and in the developments on the St. Maurice River in Quebec.

Among the great works in the Niagara district a number are worthy of special mention. The American Cyanamide Company, which also has extensive works at Muscle Shoals, Alabama, has a capacity in its Canadian plant for producing about 64,000 tons of cyanamid per annum. Among its products, in addition to cyanamid, are ammonia, nitric acid, ammonium nitrate, cyanides and argon. It has recently erected works on the New Jersey side of New York Harbour for the manufacture of ammonium phosphate, sulphate of ammonia and ammoniacal liquor. The supply of cyanamid for the New York works hitherto has been drawn largely from the Canadian works, but the supply will now be supplemented by the product made in Alabama. The phosphate rock used in making ammonium phosphate, I may add, comes from a mine the company recently acquired and is operating in Florida. There is also the Canadian Aloxite Company, whose product is carborundum, and the Acheson Graphite Company, which supplies large graphite electrodes for electric furnaces.

The Turnbull Electric Metals Company supplies low phosphorus content pig-iron, and the Exelon Company silicon carbide.

The Union Carbide Company has an output of calcium carbide of approximately 125 tons per day, and the Electro-Metals Company manufacture on a large scale ferro-silicon and electric furnace electrodes.

The Riordan Pulp and Paper Company has developed a plant for manufacturing calcium chloride from lime and salt for bleaching purposes, and as a by-product it produces caustic soda to the extent of about 35 tons per month.

In the River St. Maurice district we have, at Grand Mere Falls, the Laurentide Pulp Mills, producing about 250 tons of paper per day. At Shawinigan the Northern Aluminium Company and the Belgo-Canadian Pulp and Paper Company, have very extensive works. The Shawinigan Electric Metals Company, is a product of the war, and produces large quantities of magnesium of a guaranteed minimum purity of 99·5 per cent.

The Canadian Carbide Company and the

Canadian Electrode Company have large plants as well; but of all the developments which have taken place at Shawinigan the activities of the Canadian Electro Products Company are, from a scientific point of view, probably the most interesting. This company, under the direction of Mr. H. W. Matheson, has developed a process for making acetic acid, acetone, and allied chemicals synthetically from acetylene gas. Its present plant, which is the largest of its kind in the world, was commenced in May, 1916, and the first acetone was turned out in December of the same year. The complete plant consists of twelve buildings, representing an investment of approximately $2,000,000.

With reference to the process itself, this consists of:—

(1) The conversion of acetylene gas to acetaldehyde in the presence of sulphuric acid and a mercury salt. The acetylene gas used in this process is generated in what is probably the largest acetylene gas-generating station in existence.

(2) The acetaldehyde is converted to acetic acid by oxidation in the presence of a catalyser.

(3) The glacial acetic acid is decomposed in the presence of a catalyser into acetone. One of the most striking features of the new process is the fact that glacial acetic acid of over 99 per cent. strength is obtained from the stills on the first run, thereby assuring quick and economical production of this very essential product. As air is used in this process for oxidising the acetaldehyde into acetic acid, vast quantities of high purity nitrogen are left over, and at present are allowed to go to waste. With the supplies of calcium carbide available at Shawinigan, we may expect to see this nitrogen used before long for the production of cyanamid, ammonia, and nitric acid, ammonium nitrate and cyanides.

In dealing with the industrial development at Shawinigan, one cannot help referring to the new and vastly better conditions of living which the introduction of hydro-electric power assures for mankind. The town of Shawinigan is typical. It is scarcely twenty years old. It is beautifully situated among the Laurentian Hills. Here there is no smoke to darken the sky. The streets are well paved, and the houses are attractive architecturally. An elaborate town-planning scheme has been adopted, and all community and private property conforms to it. Large sums have been spent on community enterprises, including clubs, auditoriums and schools. As the industries are all highly technical, a minimum amount of unskilled labour is required. Large numbers of technical engineers of all grades are employed, and these, from the nature of their work and from the attractive surroundings, find their life a very profitable and a very happy one.

Had time permitted, reference might have been made in detail to interesting developments which have taken place in regard to the production of alcohol in Canada. This country, as you know, has gone "dry," with the result that all the distilleries are now directing their attention to the production of alcohol for industrial purposes. At present, alcohol is being made from grain, molasses and potatoes. This, of course, involves a great waste of valuable food products, and as the molasses is all imported the industry, from a national point of view, is not economically sound. The Advisory Council on Scientific and Industrial Research, is directing attention to this matter, and we shall probably see an attempt made soon to utilise the sawdust and wood waste of British Columbia, Ontario and Quebec, as well as the waste sulphite liquor from the pulp-mills of these Provinces, for the production of alcohol in considerable quantities.

In concluding this paper, I wish to acknowledge the help I have received from my assistants —Captain McTaggart, Mr. V. F. Murray, and Mr. R. T. Elworthy. I am also indebted to Mr. John Patterson, of the Meteorological Office of Canada, for collecting for me numerous pamphlets and published papers, as well as much collateral information.

Through the kindness of Sir Adam Beck, Chairman of the Hydro-Electric Power Commission for Ontario, and Mr. Gaby, Chief Engineer of the Commission, I have been able to lay before you much authoritative information regarding the activities of that organisation. The publications of the Water Powers Branch of Canada, under the direction of Mr. J. B. Challies, and the pamphlets prepared by Mr. A. V. White for the Commission of Conservation of the Dominion, I have also found most useful and helpful.

DISCUSSION.

THE CHAIRMAN (Mr. Alan A. Campbell Swinton) said the paper was really an encyclopædia of the industries of Canada, and gave an idea of them very different from that which obtained only a few years ago, when Canada was looked upon chiefly as the home of agriculture and furs, and things of that kind. From the paper it would be seen that the country had developed enormously, particularly in the way of utilising water-power for electro-chemical purposes. That, no doubt, would

further develop to a very much greater extent, since the 19,000,000 h.p. that Canada had in water-power was more than the whole of the water-power in the United States.

Professor H. E. Armstrong, F.R.S., said that, having twice crossed Canada from east to west, he was perhaps in a better position than some to appreciate the wonderful opportunities which Canada presented, and to form an opinion of the extent to which developments had taken place in recent times. The paper was extraordinary in the mass of information it brought forward, showing the rapid way in which the lessons of science were being learned in Canada. But those lessons had been forced upon us by our enemies. The author had called attention in various ways to the importance of research and pointed out that, in Canada, there had been formed a body which corresponded to the Advisory Committee in this country. He hoped that the Canadian organisation might be prepared to improve on the methods adopted in this country, in one respect in particular. He noticed in the early reports that our Committee was always talking of action that was being taken to prevent overlapping, but he hoped the author would urge on Canada to overlap in every possible direction: because it was necessary to recognise that scientific ideas flowed only slowly; they originated in a few minds, in curious ways; therefore it was very essential that inquiries should be started not by one person, nor by one set of persons, but by a variety. If good were to be done by instituting scientific inquiry, it would only be by giving the utmost freedom, and he believed from that point of view the policy set forth by the Committee here was an entirely unscientific one. He would like specially to emphasise the point made with regard to the democratic tendency of the universities in Canada in appointing the Professoriate; they did not prevent overlapping by appointing one professor but appointed a whole series of professors, paying them more nearly at the same rate. That certainly was a method of encouraging men in the future and the method that needed to be adopted here. Years ago he had urged that the system of paying the headmaster of a school a high salary and starving the staff was a wrong policy; it would be very much better to have a number of heads of departments paid well and a head appointed from them for a limited period at slightly higher pay. The problem of getting good men into schools would never be solved until the men were put more on a level, and were not discouraged in the earlier part of their career by being paid starvation wages. The point of greatest importance in the paper was the reference to the water-power of Canada. The available energy of the world seemed almost to be concentrated in that country, and the question was whether a good deal more ought not to be done at the present time than merely to make use of that energy for the purposes of Canada alone—whether we should not contemplate the use of Canadian water-power as a means of saving our coal. So long as coal was being used we were living on capital, but in using water-power we were living on income. Those who had worked under Government knew that in some cases it was usual to make grants returnable if not used within the year. The water-power grant was one that must be used at once, and was not returnable to anybody. The question was whether we ought not to our fullest capacity to avail ourselves of water-power and so save coal. The proposal to exchange coal against water-power with the United States was not a desirable one; something which was produced out of income would be a better exchange. It was necessary to look forward in the future to industries requiring raw materials which were to be had on the spot, or raw materials which were easily transported, being developed in the water-power countries, and not in countries where it was necessary to use coal for the purpose. Coal would become more and more difficult and costly to get, and this country would be forced to allow some of its industries to go to Canada to be worked by water-power—industries which were carried out here with the aid of coal.

Sir Robert A. Hadfield, Bt., D.Sc., F.R.S., said he happened to know of a few things that had been going on behind the scenes, and could say most authoritatively that this country was very greatly indebted to the able help rendered by Professor McLennan. Those who were asked to furnish steel of very great purity had many problems put to them by the Professor. A man might be making steel with not more than ·002 sulphur and phosphorus, but Professor McLennan was not satisfied with anything of that nature, and asked for a purity of something like ·0002, and therefore it could be imagined he set a problem to the British maker. It was gratifying to know that the makers succeeded, and by that means were able to give a good deal of trouble to our enemies. The Professor's sagacity exceeded the cunning of the enemy, and they suffered very much from the little arrangements he provided for them. He himself had not visited Canada for a good many years, but he had been very much interested when there in seeing the grand possibilities. Canada was described as the Lady of the Snows, but she might very well be described as the Lady of the White Coal; she had enormous stores of power locked up which could not be taken advantage of before electrical energy was harnessed to the service of man. Everyone knew the great part that Canada had played in the war, and they would be still more proud of her in the future in regard to the development she was carrying out in scientific and industrial movements. His mouth watered very much at the price of electrical energy in Canada, where water-power could be obtained at something like 11 to 40 dollars per h.p. per year. In the large manufacturing centres in the north of England the cost to-day was something like 80 to 100 dollars per h.p. per annum, and that

would give some idea of the serious disabilities under which this country was labouring at the present time. If any miners' representative was present, he would like to tell him what a very serious thing it was to talk of adding to that very heavy cost. Those who used energy on a large scale found a great difference between paying £18 per annum as against £2 5*s.* in Canada. He knew of a very large plant in Toronto which was using electrical energy for melting steel on a great scale, and they obtained that power for something like 10*s.* to 12*s.* a ton, whereas in the north of England to-day they were paying as much as 50*s.* to 55*s.* a ton. That hampered British manufacturers in their endeavour to keep abreast of the times and compete for work abroad. This country was also indebted to Canada for the magnificent services she had rendered to the Empire by supplying nickel, which during the war was of the highest possible importance for the production of war materials. To show the value of it, he believed there was not to-day a single nickel coin left, every one having been used up by the Germans for war material. In the same way Canada supplied ferro-chromium. He would like to know whether the author could hold out any hope of this country being able to get supplies of manganese ores from Canada, as the world was none too plentifully supplied with them. It was a very important mineral, from which was extracted manganese, which was used to produce ferro-manganese, and was so valuable in the manufacture of steel of all kinds. He agreed with Professor Armstrong that the free development of industrial and scientific research should not be hampered in this country. While he was sure the Council for Industrial Research wished to give every possible help, they should see that the development of invention was not hampered by restrictions. When rules and regulations were formed through Government offices red-tape began to appear, and there was hampering at once.

Mr. H. E. M. Kensit said he had listened to the paper with very great interest, especially to the portion which referred to the hydro-electric developments with which he was more particularly concerned. The figure given by Professor McLennan of 2,300,000 h.p. was not an estimate, but was the result of a recently completed census made by the Dominion Water Power Branch and by the Dominion Bureau of Statistics in the most thorough manner, and that figure represented 126 per cent. increase in eight years in the power developed. To that must be added about 400,000 h.p. of new construction work now actually in hand. The figure of 2,300,000 represented about 70 per cent. of all the hydro-electric development in the whole of the British Empire. Canada was not behind any other country in hydro-electric engineering practice. Taking eight of the leading stations, they averaged 150 h.p. installed in each, and four of those stations were designed for an ultimate capacity of 180,000 to 260,000 h.p. each. There was also the new development of the Hydro-electric Power Commission on Niagara River of 300,000 h.p. The author had mentioned the units of 52,500 h.p. that were being put in there, and he would like to emphasise the point that those units were more than double the capacity of any hydraulic turbines that had been yet built, and it required considerable enterprise and courage to lay out plant and issue specifications for units of that size. The transmission system of the Hydro-electric Power Commission was the largest transmission system in the world. The Niagara portion covered an area about equivalent to that of England, from a single source of supply. The greatest length of transmission from the source was 274 miles, and the population supplied was over 1,000,000 on that one system. Taking the whole ten systems that were operated by the Hydro-electric Power Commission, they supplied 225 municipalities, and had 3,000 miles of transmission lines of various voltages. The Shawinigan Power Company also had a large transmission system, and not long ago put in for its transmission system the longest single span of overhead wire in the world, 4,800 ft. clear span across the river St. Lawrence. The electric conductors for that consisted of steel cables $1\frac{3}{8}$ in. in diameter, and the insulators weighed 6 tons each. The biggest span previously existing was that across San Francisco Bay, 4,400 ft. Even before the war Canada was a considerable manufacturing country. Owing to the practically unlimited hydro-electric power available, she was able to give tremendous help in the production of munitions of war, and this led to very great development in manufacturing facilities. This was commented on in the "Report of the Departmental Committee Appointed by the Board of Trade to Consider the Position of the Engineering Trades after the War" as follows: "*Canadian Engineering Works.*—As a matter very relevant to the consideration of International competition after the war, it is necessary to refer to the growth of engineering works in Canada since 1914. We have no details, but reports say that with a population of 8,000,000 Canada is now equipped with engineering works capable of dealing with the wants of 24 millions of people. If this is true, the competition of Canada may hereafter have to be included in any reckoning of international trade."

Professor G. S. Woodhead, M.D., LL.D., F.R.S.E., F.R.C.P.E., said there was one aspect of the paper that had not been touched upon, but which appeared to him to be quite as important as any of those that had been discussed—the question of thoroughness. Full justice had scarcely been done to the extreme thoroughness that characterised all these movements and much of the work that was now being done in Canada. Large water-power areas had been spoken of, but everybody did not realise the care and the thought that were put into the application of that power to industrial and other purposes. He thought this arose out of what the author described in the first part of his paper, the complete system of education. He had had the opportunity of seeing the work done in Toronto, where the curative sera and vaccines prepared were amongst the best he examined in the course of his military duties, and in McGill and other universities, and he had been struck, first of all, by the type of teacher, and, secondly, by the extreme care taken in the training of their workers. In this country we sometimes prided ourselves on our individuality, but in Canada they managed to get a great deal of system without sacrificing much individuality, with the result that the work there was exceptionally good. He had had an opportunity during the last year and a half of seeing many of the Canadian military laboratories in this country. He recognised at once that they were the outcome of an extraordinarily well-organised system. In many cases they seemed to have transported the whole of their laboratory and staff from Canada to this country, with the result that their staff, their apparatus, and their laboratory

facilities were certainly more complete than those we had been able to organise—of course, at comparatively short notice—in this country. They had in Canada a large number of forceful, energetic and well-trained men who had made up their minds that whatever they did should be of the highest class. Along with their centralisation they were organising communication. It did not matter whether it was in research or in business, they first of all centralised fairly completely and then made free communication between various departments, with the result that the work done not only covered a wider area, but had a tendency to go deeper. Developments in Canada had been enormous, due to the concentration that was brought to bear on the various problems that were being studied. They were utilising the power at the source, a thing we should have to do. Canada must compete with us, and unless we utilised our remaining natural resources on the spot and did not waste them in carrying them about from point to point, we could not hope to compete successfully with Canada, a country endowed with such great resources.

The Hon. Richard Clere Parsons, in moving a vote of thanks to the author for his most exhilarating and comprehensive paper, said it led people to consider that Canada was a very powerful rival to our own country. Owing to its use of water-power it would be saving coal, and would possess coal after the coal of every other country had been exhausted, and then it would still have its inexhaustible water-power. He hoped Canada would become a home for our surplus population in years to come.

Mr. Byron Brenan, C.M.G., in seconding the vote of thanks, said it had been shown by the author that the forces of nature, as assisted by scientific research, could be obtained in Canada for about a fourth or a fifth of the cost in England, and it was rather a dismal lookout for this country. If he had to be born again in the next century he hoped he should be born in Canada and not in the United Kingdom.

The motion was carried unanimously.

Professor McLennan, in reply, said the remarks made in the discussion had been far more kindly than he had anticipated. He wrote the paper hurriedly, and endeavoured to be modest in his statements, but he thought that all he had said could be verified. It had been a great pleasure to him to write about Canada, the land of his birth. With regard to Sir Robert Hadfield's question about manganese, he thought production in Canada was not emphasised just now in that direction, or at any rate he had not had any definite information about it.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 24...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor W. A. Bone, "Coal and its Conservation." (Lecture III.)

East India Association, 7, Tothill-street, Westminster, S.W., 3.30 p.m. Lieut.-Colonel James Bedford, "The Salvation Army Work among the Criminal Tribes of India."

Geographical Society, Burlington-gardens, W., 8 p.m. Captain A. Ogilvie, "Macedonia."

Tuesday, March 25...Metals, Institute of, at the Chemical Society, Burlington House, Piccadilly, W., 4 p.m. 1. Captain G. D. Bengough and Dr. O. F. Hudson, "Fourth Report to the Corrosion Research Committee." 2. Dr. W. Rosenhain and Mr. D. Hanson, "The Properties of some Copper Alloys." 3. Lieut.-Colonel C. F. Jenkin, "Metallurgical Information Required by Engineers."

Fédération Britannique des Comités de l'Alliance Française, at the Royal Society of Arts, John-street, Adelphi, W.C., 5.30 p.m. Lecture by Professor Diehl.

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Scotland." (Lecture II.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Discussion on following papers:— 1. Messrs. J. Caldwell and H. B. Sayers, "Electric Welding Developments in Great Britain and the United States of America." 2. Mr. W. S. Abell, "Experiments on the Application of Electric Welding to large Structures." 3. Mr. J. R. Smith, "The Application of Electric Welding in Ship Construction and Repairs."

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. C. A. Hackman, "The Photographer's Pencil."

Colonial Institution, Hotel Cecil, Strand, W.C., 8 p.m.

Industrial Reconstruction Council, 2, Tudor-street, E.C., 6 p.m. Mr. F. W. Sanderson, "Industry and Educational Reconstruction."

Wednesday, March 26...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Professor A. H. Gibson, "British Engineering and Hydro-Electric Development. (The Training of Engineers.)"

Aeronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Lieut.-Colonel T. R. C. B. Cave, "Lighter-than-Air Craft."

Geological Society, Burlington House, W., 5.30 p.m.

Labour Co-partnership Association, Kingsway Hall, Kingsway, W.C., 4.30 p.m. Mr. E. O. Greening, "A Great Store—Bon Marché, Paris."

Metals, Institute of, at the Chemical Society, Burlington House, Piccadilly, W., 4 p.m. 1. Messrs. D. Hanson and S. L. Archbutt, "The Micrography of Aluminium and its Alloys." 2. Mr. O. W. Ellis, "Effect of Work on Metals and Alloys." 3. Mr. F. Johnson, "The Influence of Cold Rolling upon the Mechanical Properties of Oxygen-Free Copper." 8 p.m. 1. Dr. W. Rosenhain, "Science and Industry in relation to Non-Ferrous Metals." 2. Mr. W. R. Barclay, "The Relationship between the Laboratory and the Workshop." 3. Mr. F. C. A. H. Lantsberry, "The Scope of the Works' Laboratory."

Thursday, March 27...Cold Storage and Ice Association, at the Royal Society of Arts, John-street, Adelphi, W.C., 5 p.m.

Pottery and Glass Trades' Benevolent Institution, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, W., 8.30 p.m.

Britain and India, 7, Southampton-street, Holborn, W.C., 3 p.m. Mr. H. S. L. Polak, "India Overseas."

Royal Institution, Albemarle-street, W., 3 p.m. Professor C. H. Lees, "Fire Cracks and the Forces producing them." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. C. A. Hackman, "The Photographer's Pencil."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Paper by the late Mr. H. R. Constantine, "The Co-ordination of Research in Works and Laboratories." (To be read by Mr. J. S. Highfield.)

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. J. S. E. de Vesian, "Ferro-Concrete Ships."

Friday, March 28...Munitions, Ministry of, at the Royal Society of Arts, John-street, Adelphi, W.C., 9.15 a.m. to 4 p.m. Conference.

London Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 5 p.m.

Royal Institution, Albemarle-street, W., 5.30 p.m. The Right Hon. Sir J. H. A. Macdonald, "The Air Road."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. Sir R. T. Glazebrook, "Metrology in the Industries."

Saturday, March 29...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Spectrum Analysis and its Application to Atomic Structure." (Lecture IV.)

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—March 21, 1919.

No. 3462. MARCH 28, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers over three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,462. VOL. LXVII.

FRIDAY, MARCH 28, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 31st, at 4.30 p.m. (Cantor Lecture.) PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." (Lecture I.)

WEDNESDAY, APRIL 2nd, at 4.30 p.m. (Ordinary Meeting.) W. NORMAN BOASE, C.B.E., Chairman of the Flax Committee for Scotland, "The Cultivation and Preparation of Flax, and the Linen Industry." SIR FRANK WARNER, K.B.E., President of the Textile Institute, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

INDIAN AND COLONIAL SECTIONS.

A joint meeting of the Committees of the Indian and Colonial Sections was held on Friday, the 21st inst. Present:—

Sir (Frederick) William Duke, G.C.I.E., K.C.S.I. (Chairman of the Indian Section Committee), in the chair; Lord Blyth (Chairman of the Colonial Section Committee), Sir Charles H. Armstrong, Sir Charles S. Bayley, G.C.I.E., K.C.S.I., R. E. Brounger, Laurence Currie, M.A., J.P., Sir Frederic W. R. Fryer, K.C.S.I., Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc., Sir H. Evan M. James, K.C.I.E., C.S.I., Major E. H. M. Leggett, R.E., D.S.O., Major-General Beresford Lovett, C.B., C.S.I., Lieut.-Colonel Sir Thomas Bilbe Robinson, K.C.M.G., K.B.E., Colonel C. E. Yate, C.S.I., C.M.G., M.P., with G. K. Menzies, M.A. (Secretary of the Society), and S. Digby, C.I.E., (Secretary of the Indian and Colonial Sections).

CANTOR LECTURE.

On Monday afternoon, March 24th, PROFESSOR W. A. BONE, F.R.S., delivered the third and final lecture of his course on "Coal and its Conservation."

On the motion of the Chairman, Dr. M. O. FORSTER, F.R.S., a vote of thanks was accorded to Professor Bone for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 26th, 1919; ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Batliwala, Dr. S. S., L.M. & S., J.P., Bombay, India.
Bond, E., London.
Burbury, Henry Herbert Taylor, J.P., Wakefield.
Crowe, W. M., London.
Hall, Benjamin James, Eastcote, Middlesex.
Hogg, Malcolm Nicholson, Bombay, India.
Johnston, Major Cecil Hugh Ralli, R.A.F., A.M.Inst.A.E., London.
Murdoch, Richard Alexander, Bombay, India.
Taylor, Robert, Oldham, Lancashire.

The following candidates were balloted for and duly elected Fellows of the Society:—

Critchley, Captain James Sidney, R.A.S.C., M.I.Mech.E., M.I.A.E., Cleveland, Ohio, U.S.A.
Foster, Captain Fermian Le Neve, Pinner.
Harding, Charles Victor Malim, Toronto, Canada.
Henderson, Captain Thomas, M.C., R.A.F., Tynemouth.
Monro, George, Jun., London.
Simpson, Arthur Tate, A.M.I.A.E., Hull.
Staite, Edward Henry, A.M.I.A.E., Bristol.
Summers, Captain Lynar Frederick, R.A.S.C., London.
Woolley, A. Herbert, Nottingham.

A paper on "British Engineering and Hydro-Electric Development (The Training of Engineers)" was read by ARNOLD HARTLEY GIBSON, D.Sc., M.I.Mech.E., Professor o Engineering, University College, Dundee.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, March 6th, 1919; The Right Hon. LORD CARMICHAEL, G.C.S.I., G.C.I.E., K.C.M.G., in the chair.

THE CHAIRMAN, in introducing the reader of the paper, said Mr. Gourlay was his private secretary the whole time he was in Bengal. He could say without any exaggeration that if he did anything worth doing in Bengal it was mainly because of Mr. Gourlay, and he would have avoided one or two mistakes he made if he had followed Mr. Gourlay's advice.

The paper read was—

THE NEED FOR A HISTORY OF BENGAL.

By WILLIAM ROBERT GOURLAY, C.I.E., I.C.S.

I feel some trepidation in venturing to address the Indian Section of the Royal Society of Arts, because the majority of those who have enjoyed this honour have been scholars or men of wide administrative experience, and they have given you of their scholarship and of their wisdom. I have no claim on these grounds to enjoy the honour; and when I accepted the invitation of your Committee in order that I might have an opportunity of bringing to notice what I believe to be a great need at the present moment, I fear I did not realise that I should address an audience of such scholarly attainments as I see here this afternoon. And when I came to put my thoughts into words I realised how little I knew of the subject. I would ask for your indulgence therefore. I have, I fear, nothing to tell you which is not known to many here present far better than to myself, but I hope that by recalling to your memories facts you know already I may be able to give you some pleasure, just as one finds pleasure in looking at photos of well-remembered scenes even though the photographer is an indifferent artist.

I went to Bengal over twenty years ago, and I have read Indian history—when I had the opportunity—and more particularly the history of Bengal, not as a scholar, for I regret to say I have not a scholarly knowledge of any Indian language, but as a student anxious to learn something of the people among whom I was living, and I have experienced the difficulty of finding books dealing with the subject. So far as I am aware there is no one book from which a clear connected history of Bengal can be obtained. I well remember my disappointment when I learned that I was not to be posted to the Upper Provinces. I had read in the histories of Marsham and of Elphinstone of the glories of Delhi and of Agra, and I imagined that Bengal was an area of mud flats without a history of any interest to the student. The history of the early days of John Company I had associated with India in general and not with the Province of Bengal. One day, in the Bayley Library at Midnapore, I found Marshman's outline of the History of Bengal, and from a perusal of its pages I was led to seek for a copy of Stewart's History. It was not till long after that the Asiatic Society of Bengal published Abdus Salam's translation of the work of Ghulam Hussein, and, with the exception of Barton's little book, these are the only works I know of, which deal exclusively or at all comprehensively with Bengal.

Bengal is but a fraction of the Indian Empire. It covers 78,000 square miles out of a total area of 1,773,000—less than one-twentieth of the whole. Its population amounts to 45,500,000, less than 15 per cent. of the population of India, but a population greater than that of the United Kingdom. The importance of the country lies not only in the fact of its large population, but in the fact that the Bengalees as a people possess many of the qualities which go to make a nation. They are not a congeries of peoples. They are a distinct race, inhabiting a compact area, with a living language and literature of their own, with a continuous history covering a period of a thousand years. They are, moreover, a highly intellectual people; and ready to take advantage of the benefits of education. Sometimes the people are thought of as belonging to two distinct classes, the *intelligenzia* (as the one class is sometimes called) and the masses—for the most part cultivators. But this is, I think. a superficial test of the intellectuality of the people. There is no hard and fast division between the cultivating classes and the professional classes. Sons of the cultivators, when they receive the advantages of education, have no difficulty in taking their place among the professional classes; and many of the chief professional men of Bengal to-day are the sons of humble villagers. These thoughts lead one to believe that the people of Bengal are likely to take a leading part in the development of India, and consequently, I think, in the future of the British Empire.

From what I hear said by people who have had no opportunity of becoming acquainted

with Bengalees at first hand, I think it is possible that in this country, and perhaps also in other countries, there is considerable misapprehension regarding the character of the Bengalees as a race. Anstey's dialogues were at one time widely read in England. Their delightful humour is appreciated by many Bengalees, who see in them the caricature of the weaker points of the young Bengalee who is studying in England, just as they appreciate the caricatures of the Europeanised Bengalee in India portrayed by Gugunendranath Tagore in his recent sketches; but Mr. Jabberjee no more represents the national character of the Bengalee than Mr. Crosland's "Unspeakable Scot" represents my fellow-countrymen. Nor are the doings of the gang whose machinations are described in the recently published report of Mr. Justice Rowlatt's Committee characteristic of the people any more than the members of the brotherhood of the Black Hand are characteristic of our American brethren. But I fear it is possible that the perusal of these pages of Anstey and of the Rowlatt Committee's report have prejudiced many Englishmen against the whole Bengalee race.

Mr. E. C. Carter, who is known to some of you as the organiser of the American Y.M.C.A. in France, and was until recently at the head of the same organisation in India, used to say to the men who came out to help him: "Find some Indian young man and make a friend of him, and you will accomplish more that way than any other." The result of Carter's advice is known to all who have seen what the Indian Y.M.C.A. secretaries in France, in India, in Mesopotamia, and in Africa have done for the soldiers of the King. Similarly, I would say: "If you want to understand Bengal, find some young Bengalee and make a friend of him." I do not mean an acquaintance when I use the word friend—I mean a real, true friend; a man you can be as open with as you are with the best friend you have of your own race: a man whom you regard from the same point of view as you do your own brother. Government records are full of the advisability of every officer in India acquiring a good knowledge of the vernacular, and perhaps sometimes we forget that a knowledge of the vernacular is only one means to the desired end—an understanding of the people—and that no officer will ever understand the people and appreciate their aspirations unless he makes among them at least one true friend. It is not a question of acquiring a knowledge of customs and observing rules of courtesy. It is a question of true friendship, a relationship which can exist only amongst people who regard one another as equals, which looks through all the rubbish and imperfections and reaches out to true knowledge. When anyone talks slightingly of the people of Bengal, it is a good plan to inquire as to his Bengalee friends, and then estimate the value of his opinions accordingly.

The Bengalees gave way before the first organised military power which desired to subjugate them, and for over 700 years they have been subject to rulers of alien race. The British Government has maintained peace within the borders of their land, and during the period of this administration the race has taken advantage of the blessings of peace.

In Bengal there are 45 million people who speak a common language, and who constitute 99 per cent. of the population. These people are highly intellectual, deeply emotional, and above all religious. In recent years they have developed a strong national sentiment. Were it not for their great religious differences—the proportion of Mohammedans to Hindus is as eight to seven—and for the caste cleavage common throughout India, one would predict a great future for them as a nation, and signs are not wanting that the people are, both consciously and unconsciously, making efforts to place the sentiment of nationality above that of religious or social distinctions.

It is for these reasons that I think there is to-day a great need for a History of Bengal. We want a readable book which we can place in the hands of the people of England and of India, which will give the facts concerning the history of this people from their early beginnings up to the present time. Everyone would then have an opportunity of understanding how Bengalees have come to occupy their present position, and what their aspirations are, and we might then, through a knowledge of the past, look into the future, and thus find guidance for the present.

The first problem the historian would have to settle is the definition of "Bengal." The term is associated to-day with an Administrative Province. The area includes the district of Darjeeling on the north, peopled by hill tribes, and some outlying portions of the Chotanagpur plateau inhabited by non-Aryan races; and it excludes some Bengalee-speaking areas on the west (included within the Bihar and Orissa Province), and others in the east (included in Assam); but the historian's attention would,

I doubt not, be fixed upon the development of Bengalee-speaking people who inhabit the delta of the Ganges and Brahmaputra river systems. He would find, however, that in early days the centre of the development of the people was in the neighbouring Province of Bihar, where the centre of the civilisation of India was to be found in the ancient kingdom of Magadha; and in later times his area would have to include not only Bengal, but Bihar and Orissa as well.

The first Englishman to attempt a History of Bengal was Charles Stewart, professor of Oriental Languages in the Honourable East India Company's College. In 1813 he published "The History of Bengal from the First Mohammedan Invasion until the virtual Conquest of that Country by the English, A.D. 1757." In his preface Stewart wrote: "To those therefore who are looking forward to Bengal as their place of sojourn for several years, a work which faithfully details the events that have been transacted in the country they are about to visit, will, I should hope, prove both instructive and interesting, and to those who have already been resident in the East it may be presumed to afford some pleasing reflections by recalling to their minds scenes where many of them will probably acknowledge they have spent the happiest period of their lives. To a few the subject of this book will be no novelty; but those gentlemen will probably confess that they acquired their knowledge at the expense of much time and application, a part of which they would gladly have spared." The work is composed of translations made by himself from the works of Persian historians. The chief of these were the "Tubkat-Nassiry," a work published in A.D. 1258–9, the "Tabkat Akbery," written about 1600, the "Akbar Nameh of Abul Fazil," the "Tarikh Ferishtah," written about 1609, and, most important of all, the "Ryaz Assulateen," "a history of Bengal from the earliest period of authentic antiquity till the Conquest of the Country by the English," written in 1787–8 by Ghoolam Hussein Seleemy; the same author's "Seir Mutakhereen," or "View of Modern Times," a general history of India from the year A.D. 1706 to 1780, finished n 1783.

The next attempt (so far as I am aware) to present the history of Bengal in a readable form, was that made by J. C. Marshman, the son of the great missionary, who in 1864 compiled for the use of youths in India, "a brief and simple outline of the History of Bengal." This was the text-book in Bengalee schools for many years. It gives a brief sketch of the history of the country from the Mohammedan invasion in the end of the twelfth century to the close of Lord William Bentinck's administration. For the Mohammedan period Marshman was indebted to Stewart's work, and to more recent translations of the "Seir Mutakherin" and Ferishtah's History.

In 1874 a member of the Civil Service, named Barton, published a very readable little compilation entitled "Bengal: an Account of the Country from the Earliest Times with full information with regard to the Manners. Customs, Religion, etc., of the Inhabitants, and the Effects of British Rule there." In 1903 Maulavi Abdus Salam, of the Bengal Provincial Service, published, under the auspices of the Bengal Asiatic Society, a work entitled "The Riyazu-s-salatin: a History of Bengal by Ghulam Hussein Salim, translated from the original Persian," the work which formed the basis of Stewart's history.

So far as I am aware these are the only works available to the English reader which deal at all comprehensively with the history of Bengal. None of them is easily accessible to the public, and none of them deals with the subject really comprehensively or in accordance with modern ideas of historical research and criticism.

The future historian of Bengal will probably divide his work into three parts. In the first he will deal with the period of Hindu civilisation prior to the Mohammedan invasion in the end of the twelfth century. The second will probably be devoted to the Mohammedan rulers. While the last—and from the point of view of the people's development—the most important part will deal with the history of the country from the time when the influence of the European trader was first felt to the present day. The dates which divide these periods are 1198, the year when the Mohammedan raiders entered Bengal, and 1757, the date of the Battle of Plassey.

The recovery of the lost history of the Hindu period is the work of the present generation. You all know what Mr. Vincent Smith has done to recover for us the lost history of India. In Bengal Rakhaldas Bannerjee, his devoted admirer, has followed in his footsteps. In his "History of Bengal," written in the Bengalee language and published in 1914, Rakhaldas Babu has woven into a connected account the facts retrieved by archæological research. Other scholars who have dealt with this early period are the learned Shastri Sahib, Haraprasad

of Calcutta, and the two chief workers of the Varendra Research Society—Akhoy Kumar Maitra, the director, and Ramaprasad Chandra, the secretary.

The Hindu period can conveniently be divided into three chapters, the first dealing with the early period prior to the rise of the Pala Dynasty of Bengal in the end of the ninth century; the second dealing with the great Buddhist Empire of the Palas; the third dealing with the reaction of Brahminical Hinduism, the overthrow of the Palas, the reign of the Senas, and the development of those disruptive forces which made Bengal an easy prey to the Mohammedan invaders.

The materials for writing these chapters are accumulating yearly. Old manuscripts still yield references which hide relevant facts; and scholars are always hopeful that treasures may yet be found in the ancient libraries of Tibet which will throw light upon the close connection which existed at that period between Tibet and Bengal. Chinese records, too, may yet yield accounts of travellers like Fa Hien and Hiuen Tsang. Throughout Bengal itself there are ancient sites awaiting the spade of the archæologist. The Varendra Research Society, which has its headquarters at Rampur Boalia, has already undertaken work in this direction, and the success which has attended their efforts gives great promise for the future.

At present, however, it is impossible to write a connected history of the country prior to the election in the eighth century of Raja Gopala, the founder of the Pala dynasty of Bengal. Previous to this date the historian has to be content with inferences drawn from the state of affairs in the neighbouring kingdoms in Bihar, and to scattered references in works dealing with the affairs of those kingdoms. In recent years a work on political science written probably shortly after the invasion of Alexander the Great by the minister of the founder of the Mauroyain Empire has yielded valuable information about the state of the country in 300 B.C. The Chinese traveller, Fa Hien, throws some light on conditions about seven hundred years later, towards the end of the Gupta Empire; and his fellow-countryman, Hiuen Tsang, tells us something of Bengal in the days, two hundred years later, when Bengal was part of the Empire of Harsha Varddhana. The facts known about these early days have been brought together in the interesting papers of the Hon. Mr. Monahan of the I.C.S., which appeared in 1916–1917 in the pages of "Bengal Past and Present." The outstanding fact of this early period is that from the time of the invasion of Alexander the Great to 800 A.D. the centre of Indian civilisation in Northern India was, for the greater part of the time, at Pataliputra—the modern Patna—and this fact must have greatly influenced Bengal through which passes the Ganges, Patna's great waterway to the sea.

The second chapter would deal with the rise of the Pala dynasty, and the sway of the Pala kings, not over Bengal only, but over Bihar and even beyond. There is every hope that the ancient sites of the capital cities of these monarchs, situated for the most part in the Barind of Northern Bengal, will yield to the historian a fairly clear account of the facts of this great dynasty. Already Babu Rukhaldas Bannerjee has arranged the materials into a connected history. The great outstanding fact of this dynasty is that the kings were followers of the doctrine preached by the Lord Buddha, but that they tolerated other religions is proved by the fact that their ministers were often Brahmans. The Pala Empire was founded by Gopala and his son Dharmapala, and at its greatest extent included not only Bengal and Bihar, but also Orissa, in the south; part of Assam on the east; part of Kamboja (probably the Lower Himalayas towards Sikkim and Bhutan); and a large part of Northern India, perhaps as far as the Punjab. There were eight sovereigns in direct descent from Gopala, whose reigns extended over a period of nearly two hundred years.

But the religion of the Brahmans was by no means on the decline; there must have been a constant fight between the Brahmanism of the priests and the Buddhism of the rulers, of which the records that we possess give us very little account, and the third chapter of the history of this period would deal with this fight and its results. The subject is at present being investigated by the learned Mahamaho-padyaya Haraprasad Shastri, from whom we may soon hope to have a monograph on this period. The Buddhist dynasty came to an end in the early part of the eleventh century, and its place was taken for a short time by the Hindu dynasty of the Senas. Raja Lukhshman Sen, the last of the Hindu kings of Bengal, was in 1198 driven out of Nadia, where he had established a capital, by the Mohammedan general, Bakhtiar Khilji.

From 1198 to 1757 Bengal was ruled by the Mohammedans. For a century and a half the rulers acted as Viceroys of the Sultans of Delhi,

until in 1338 the mad freaks of Mohammad Tughlak Shah caused the dismemberment of the Delhi Empire. For two hundred years thereafter the kings of Bengal were independent, and one of them, Sher Shah, by sheer force of character, defeated the Moghul Humayun, and himself became Emperor, and thereafter Bengal was ruled again by Viceroys in the name of the great Moghul.

Of this Mohammedan period, Ghulam Hussein is the great historian. Ghulam Hussein was the postmaster at Maldah when Mr. Udney (Carey's friend) was factor on behalf of the East India Company. The Factory at Maldah was within a few miles of the ancient capital of Gaur, on the one hand, and of the great city of Panduah on the other. He took interest in the remains at these places of the great public buildings of the Mohammedan rulers, and being impressed with Ghulam Hussein's great knowledge of their history, he encouraged him to write a history of Bengal. "Accordingly"—to quote from Ghulam Hussein's humble preface—"the order was given to this man of poor ability, that whatever he might gather from historical works, etc., he should compile in simple language, so that it might be intelligible to all and might deserve the approval of the *élite*. This ignorant man of limited capacity, deeming the execution of the order of his master incumbent on himself, being the slave of order, has placed the finger of consent on the eye, and girded up the loin of effort and venture, collected sentence after sentence from every source, and for a period of two years has devoted himself to the compilation and preparation of this history. And after completing it, he has named it "Riazu-s-Salatin" according to the date of its completion." The chronogram yields the date 1788. Ghulam Hussein divides his work into four sections, dealing respectively with the rule of the Viceroys of the Sultans, of the Mussulman kings of Bengal, of the Nizams of the Moghul Emperors, and, lastly, with the arrival of the Christians and of their "domination."

Since the time of Ghulam Hussein further researches—particularly by the great Oriental scholar, Dr. Blochmann—and discoveries of the Archæological Department, have led to the recovery of many new facts; but the "Riazu-s-Salatin" will for all time remain the foundation of succeeding histories, as it was the foundation of Stewart's work in 1813.

Ghulam Hussein's narrative, however, deals with the history of the rulers, and there is but little material in it from which to write a history of the Bengalee people. This subject has been investigated lately by Professor Jn. Das Gupta, of the Presidency College, Calcutta, who has searched the early literature of the Bengalee language, and has extracted from it much interesting information concerning the life of the people during the period of Mohammedan rule.

The future historian, following in the wake of Ghulam Hussein, would probably divide this period into three chapters: The first might be named "Bengal, a frontier Province of the Delhi Sultanate, 1198 to 1338." The second might have the heading, "Bengal under Independent Kings, 1338 to 1538." The third would deal with "Bengal: a Province of the Moghul Empire."

The first of these chapters would open at the time when Qutbuddin ruled at Delhi as Viceroy of the Ghorian Emperor. The warriors from the mountains of Afghanistan were in the full tide of conquest, and one of the generals, Bakhtiar Khilji, made a raid into Bengal, met with no opposition, turned the old King Lakhshman Sen out of Nadia and occupied the chief city of Gaur. The years which followed were times of wild frontier warfare. Mohammedan soldiers formed extensive baronies in different parts of Bengal, and yielded a more or less unwilling allegiance to a Viceroy at Gaur, whose loyalty in turn to the Emperor varied directly with the power wielded from Delhi. Ibn-i-Batutah, the great traveller, visited Bengal in 1342, and he has given us some account of the state of the country at the time immediately following these wild days. The temptations offered by the madness of the Tughlak Emperor, coupled with the weakness of a Bengal Viceroy, were too great for one rough soldier named Fakhruddin. He usurped the Viceroyalty, and shortly afterwards, in 1338, declared himself King of Bengal.

The second chapter of this period would deal with the two great kingly houses of Bengal, that of Haji Ilyas and that of Allau-d-din Hussein, which (except for a break of forty years) ruled Bengal for two centuries. Tribute was no longer sent to Delhi, and the kings lavished their revenues on public buildings and mosques, and military works, remains of whose glory are to be seen to-day at Gaur and Panduah in the district of Maldah. The kingdom at one time assumed the dimensions of an Empire; the sway of the Kings of Gaur extended across the Megna on the east, as far as Chittagong. On the north the king's influence extended over Kuch Behar and Western Assam; on the east it included North Behar and the eastern portion of South

Behar, and on the south it included Orissa. It was during these early periods of Mohammedan rule in Bengal that the people of East Bengal embraced the faith of their rulers—so that to-day Eastern Bengal is predominantly Mohammedan.

In 1538 Sher Shah—a great Baron of Behar—drove the King of Bengal from his capital. The latter appealed to the Emperor Humayun, who in turn drove out Sher Shah and occupied Gaur for a few months; but Sher Shah finally recovered himself, not only drove Humayun out of Bengal, but drove him out of India, and seized for himself the Imperial throne at Delhi. Sher Shah knew the state of affairs in Bengal, and during his lifetime he ruled his Eastern Province through three Viceroys—at Gaur, Sonargaon (near Dacca), and Satgaon (near Hooghly). But the Sur dynasty, though founded by one of the greatest statesmen India ever produced, had but a short life, and the Moghuls returned to Delhi in 1556. Bengal enjoyed a short period of virtual independence, but Akbar finally defeated the last King, Daud Khan, in Orissa in 1575, and from that time to the beginning of the British Dominion, Bengal was ruled by Nazims, or Deputies of the Moghul Emperor.

For the third chapter of this period the materials for a history are much greater. In addition to the ancient histories we have the accounts of many contemporary historians, and we have the invaluable evidence of travellers like Tavernier and Bernier. There is also much material for the writing of the history of the Bengalee people during this period in the careful researches made by eminent scholars into the early records of the European traders whose connection with Bengal dates from the arrival of the Portuguese in 1515.

The Moghul Emperors adopted a form of government which was new to Bengal, but which probably had its origin in the active brain of Sher Shah. They adopted what in modern language would, perhaps, be called a "dyarchy." The Governor of the Province was the head of the military power, and to him was entrusted the executive authority including criminal administration; to another officer independent of the Governors, called the "dewan," were entrusted the financial administration and the collection of the revenue; often, too, when there was no special officer appointed for the purpose, he superintended the administration of civil justice as well. The old capital at Gaur was decimated by a plague, and in the days of Akbar, Rajmahal on the south bank of the Ganges (renamed Akbarnagar) became for a time the seat of government, but the chief military power was required in the east to defend the frontiers against the invasions of the Arakan pirates and their allies; and Shah Sujah, the Emperor's son, removed the capital to Dacca, which was renamed Jahangirnagar. For sixty years a succession of able viceroys ruled Bengal from its eastern capital, Shah Sujah, the Emperor's son; Mir Jumla, the great general; Shaista Khan (the brother of the "Lady of the Taj"), the most brilliant of all; and, lastly, Ibrahim Khan, the friend of the English merchants. Then the decay of the Moghul Empire set in. Aurangzeb died in 1707, and a change in the relations between the Viceroys and their Emperor took place. Just before Aurangzeb's death, the able revenue officer, Murshed Kuli Khan, Dewan of Bengal, showed his independence by breaking with the Governor of Bengal and removing his head-quarters from the Governor's capital at Dacca to Maxusabad, which thereafter came to be known as Murshidabad. The astute Dewan induced the new Emperor Furrukhsir, who in younger days had ruled at Dacca, to entrust to him the powers of the Governor as well as those of Dewan. Thus the old Moghul safe-guard was destroyed, and when the Emperor's power was weakening, the Viceroy's position was rendered stronger, and the Nizams of Bengal became for practical purposes as independent as the old Afghan kings. Murshed Kuli Khan ruled the Province till 1725. During the next fifteen years the Moghul Empire broke up and the *coup de grâce* was given by the Persian, Nadir Shah, in 1739. All the smaller powers—Mahratta, Mussulman, and Christian, hastened to get for themselves what they could out of the *débris*. In Bengal an able administrator named Ali Verdi Khan usurped the office of Nizam and Dewan, and ruled as an independent sovereign. For sixteen years he tried to protect the country from the raids of the Mahrattas, and in the end he was only able to secure peace by promising to pay the Chaut, and in lieu of the payment he ceded to the Mahrattas the Province of Orissa. These wars had weakened his government, and it was with sad misgivings that on his death in 1756 he handed on the sovereignty to his arrogant young grandson, Siraj-ud-Daula. One of the first acts of this headstrong youth was the capture of Calcutta in 1756. The defeat of Siraj-ud-Daula at Plassey by Clive in the following year, and the military successes of Adams and Munro, culminating in the Battle

of Buxar in 1764, laid the foundation of the British Period of Indian History.

From the commencement of the British period there is an immense mass of original authorities for the writing of the history of Bengal. The Venerable Archdeacon Firminger not long ago gave in this hall an account of the manuscript records which exist. Many of these have not yet been used by scholars. Archdeacon Firminger deserves the thanks of every one interested in the Province for his untiring labours in getting these early records printed, and the work of Sir George Forrest, Mr. C. R. Wilson and Mr. William Foster, of the India Office, is well known to you all; but so far as I know no one has yet been able to weave the material available into a connected history of the period.

The historian of Bengal would probably preface this portion of his work with two chapters, the one dealing with the advent of the European as a trader, the other with his career as a *zemindar* or landholder under the Viceroys of Bengal, and after this introduction he would devote his third chapter to the efforts of the East India Company to take the place of the old Moghul dewan, while they left the Governorship (or Nizamat) in the hands of the descendants of the Nawab Mir Jaffir, to whom Clive had given the Governorship after Plassey. This is a dark chapter in the history of British administration in India. Clive, on his return to India, did his best to straighten out matters, but he failed, and we have to thank God that he was ultimately succeeded by an able and upright administrator in the person of Warren Hastings. The history of the administration of Warren Hastings would, no doubt, form the fourth chapter.

Until 1774 the history of the British Dominion in Northern India coincides with the history of Bengal, but in that year the Governor of Bengal became the Governor-General of India, and with the constantly-increasing dominion of the East India Company the centre of political interest passes from Bengal, and, but for an important chapter, the history of Bengal during subsequent years as a separate province has not yet been written. The important chapter to which I refer deals with the settlement of the land revenue of the Province made by Lord Cornwallis in 1793. The future historian will, I doubt not, devote his fifth chapter to this intricate and controversial subject. The policy of Lord Cornwallis laid the foundation of the present social and economic condition of the Province, and, it is not too much to say, a proper understanding of the subsequent history of the people depends upon a knowledge of the terms and results of the Permanent Settlement. In this connection Archdeacon Firminger is, I believe, studying certain reports of the "Supervisors" of Bengal (the officers appointed in 1772 and the predecessors of the collectors) which came to light in the Bengal Record Rooms only recently. These contain a detailed account of the Province prior to the time of the permanent settlement, and they seem likely to throw much light on the question how far Cornwallis's policy can be justified.

After the settlement of the revenue the general histories of India seldom give any detailed consideration to the history of the Bengalee people. They are taken up with the wars in South India and in the Western Presidency, with the conquests of Wellesley and of Hastings, and it was during this time when there was peace within the frontiers of Bengal that one has to search for the roots of the modern development of the Bengalee people. Ample materials exist not only in public records —many of them hardly touched by historians— but also in the writings of travellers in newspapers, letters, biographies, especially of missionaries like Carey, Marshman, and Ward. This (the sixth) chapter would probably be called "The Dawn of Western Education." Mr. H. R. James, a scholar of Indian history, and for many years the respected principal of the Presidency College, has already prepared a manuscript on the subject which I have had the privilege of reading, and which I hope will soon be published. This period would carry the history of Bengal through the enlightened administration of Bentinck, including the momentous decision upon Macaulay's Minute on Education, up to the publication of the Despatch of 1854, which is the foundation of the educational policy which has made Bengal what she is to-day.

In the same year Dalhousie decided that it was no longer possible for the Governor-General of India to perform the duties of the Governor of Bengal, and Sir Frederick Halliday was appointed the first Lieutenant-Governor. Mr. Buckland has published two volumes entitled, "Bengal under the Lieutenant-Governors," and this would be an appropriate title for a chapter dealing with the period covering the fifty years subsequent to 1854.

From 1905 to 1918 events in Bengal have been much in the public eye, and they have been the

cause of much heated controversy. The whole object of the history will be to show how the developments of these days have resulted from the events which preceded them, and to gain from the knowledge of this chain of cause and effect wisdom to guide the destinies of the Province at the present time. During this period the Province has been administered by a succession of wise men. Sir Andrew Fraser (whose death we mourn to-day), the late Sir Edward Baker, Sir William Duke, our Chairman, Lord Carmichael, and the present Governor, Lord Ronaldshay. To give even a short account of this period would occupy more than one afternoon of your time, and I must leave this history to men more able to deal with it than myself.

The account of the history of the Province I have tried to give you this afternoon, inadequate as it is, and in details I fear wanting in scholarly accuracy, is, I trust, sufficient to make good the thesis with which I started—that there is to-day a great need for a History of Bengal.

DISCUSSION.

The Chairman (Lord Carmichael), in opening the discussion, said he had always thought there was a need for a history of Bengal. One of the first books Mr. Gourlay gave him to read when he arrived in Bengal was Mr. Barton's brochure, which he diligently read, together with Mr. Bradley-Birt's book, "Twelve Men of Bengal." That gave him some little reputation for having studied the history of the Province, a reputation mainly due to the fact that he found that other people had not read them carefully. He agreed with Mr. Gourlay's statement that he had proved his thesis that there was a need for a history of Bengal, and he was sure the audience would agree with him that Mr. Gourlay could write such a book. He hoped, however, that somebody else would be forthcoming, as Mr. Gourlay had more immediate and important work to do. There were other men available who he hoped would now seriously consider the desirability of undertaking such a venture. When he was in Bengal he was a member of the Varendra Research Society, and he always did everything in his power to encourage the work it carried out, because it amused him and appealed to his imagination. Sir Charles Bayley, in particular, did a great deal of work in connection with the old buildings in Bengal, and knew a great deal more on the subject than he could ever hope to learn. Most people thought that a Governor ought to be an authority on Indian questions, but unless a man was very much abler than he was personally he did not see how that could be, because he was not long enough in the country to make a real study of the question.

Mr. C. E. Buckland, C.I.E., in supporting the author's proposal, thought Mr. Gourlay had hit the nail on the head when he said that there was an absolute necessity for a history of Bengal, because all the existing histories were in a chaotic state and altogether inadequate. It might take the form of, say, a glorified administration report of Bengal during the many centuries that had elapsed since it first entered into history, and it should also take the shape of a research work. A great deal was now being done in the way of consulting old records. For instance, there was a little book published on the Bengalee language and literature in 1911 by Dinesh Chandra Sen, and it was well known that his old friend Haraprasad Sastri was at work on parallel lines. Much work was, he believed, going on under the ægis of the University of Calcutta, and it seemed to him that a good opportunity was presented for amalgamating that work and making a comprehensive history of Bengal. He thought the people of Bengal might very properly claim that they ought to have a complete history of the country in which they lived. Pride in their country was a very legitimate aspiration, and if knowledge of the history of their country inspired patriotism it was very much to be encouraged. He did not quite follow the author when he said that the Bengalees are not a congeries of nations, nor did he follow him in various other matters of detail. So much had been said of existing histories of Bengal that a cynic might argue there was so much on record that no more was required. If anybody took the trouble to piece together all that had been written he believed he might produce several volumes, but the result would be an amorphous mass which would not be acceptable to anybody who cared the least for literary elegance. If a history of Bengal was written, it should not only comprise a record of the wars and the kings and so on, but an endeavour should be made to write a history of the people, following the lines of, say, Green's "History of the English People." Changes had probably occurred in the rural economy of Bengal which were worth chronicling; in fact, a history of the country could only be obtained by research among the documents which were available, including the accounts of travellers. The author had drawn attention to many works, but he had not referred to a little pamphlet called "Bengal under the Mohammedans," written by the late Sir James Bourdillon, in which the author referred to a number of books he had consulted; and he felt sure that any future historian of Bengal would obtain much guidance from that little work. A true history of Bengal would enable one lie, which was very often heard, to be finally contradicted, namely, that famines were the outcome of British rule in India. As a matter of fact, famines occurred long before the British Raj ever went near India. Lessons could also be learned in regard to administration, because it must be admitted that mistakes had been made in that

direction. For instance, he did not suppose that any administrator nowadays would dream of making a permanent settlement of Bengal. That was a mistake, although it was no doubt made *bonâ fide* and with the best intentions by Lord Cornwallis. It was quite impossible to set it aside, because British faith was involved in the matter, but there was no doubt it was a mistake. He thought the question of writing a history of Bengal should be taken up by the Government of Bengal and not by the Government of India, and that would be a welcome commencement of the new system of decentralisation. The matter could not be left to private enterprise with any chance of its being carried out, because it was not easy to get publishers to take up any book dealing with an Indian subject, as there was no money in it. He suggested that a small Committee, consisting of Bengal men, say, Sir William Duke, Mr. Bhupendranath Basu, and himself, should be put in charge of the work, and that the Government of Bengal should bear the expense of it, and even if it cost a lakh of rupees for a year or two it would not be a dear investment. The history of Bengal could not be written by one man, but it would be easy to split up the work into periods and to subdivide those periods into chapters, just as the Cambridge Modern History was subdivided. He did not agree with the periods suggested by the author, and thought that probably many more would be required; but he felt the work could be carried out within a reasonable time and that it would be a success, only it must be done under the ægis of authority. The omens were favourable in that respect, because the author had influence with the authorities in Bengal, and he hoped that Lord Sinha would also facilitate the furtherance of the project.

Mr. F. H. Skrine said that he left Bengal just before the author adorned it with his presence, and exactly twenty years ago he read a paper before the Society, at a meeting presided over by Sir Steuart Colvin Bayley, dealing with the physical aspects of Bengal rather than with its people. But those two factors were intimately connected in every country. It was most interesting to analyse the effect produced by the soil and climate of a country on the human population. Why, for instance, did the Englishman who went to South Africa become an Africander, and fight against this country? Why did the Englishmen who first settled in Ireland become more Irish than the Irish themselves; and why did the Englishmen who settled in the United States become more American than the Americans themselves? In Bengal the land encroached on the sea, the silt coming down from the Himalayas to the Indian Ocean—the converse of the ordinary state of things—and in that process factors had been at work which had exercised a most disastrous effect on the people who inhabited the Province. There was no doubt that the wireworm, cholera, and the anopheles mosquito which flourished in that region, had undermined the health of Bengal, and lay at the bottom of the absence of the martial tendency of the country. Having lived among the people of Bengal for twenty-five years, he heartily agreed with the author's plea that sympathy should exist between the two races. The Bengalees responded, more than any race he knew, to sympathy and love, which were too often lacking in the administration. There was a modern history of Bengal, written from the English point of view, in which the Black Hole of Calcutta was thrown into an altogether fallacious perspective. The Black Hole was a terrible blunder, but it did not merit the obloquy which had been poured on Bengal ever since 1757. Every week throughout the great war the Germans perpetrated a thousand more crimes than the wretched boy Siraj-ud-Daula did. Bengal was a wonderful country; there being gigantic ruins of past civilisation buried in the midst of primeval forests. The whole of Bengal was teeming with relics of a glorious past, and they ought to form part of its history. If he was ten years younger he would write such a history himself, treating the Bengal nation as a living organism which would grow with sympathy and with due regard to the lessons of history.

Mr. Bhupendranath Basu said that as a Bengalee in every fibre and nerve he was most grateful for the author's words of appreciation of his people. Bengalees had laboured under very great difficulties so far as the English people were concerned. The knowledge of India which first came to an Englishman who went out to Bengal was obtained through Macaulay's brilliant essays on the lives of Warren Hastings and Clive. No scholar now attached any historical value to Macaulay's writings, but the heroes of British Indian history were so fascinating, and the young people who read them were so ignorant of India, that they accepted as the truth statements which were greatly exaggerated and sometimes unfounded. Everyone remembered Macaulay's famous indictment of the Bengalee people, which he based on the conduct of a man in the service of Siraj-ud-Daula at the time of the battle of Plassey. There was a compact between Clive and some of the councillors of Siraj-ud-Daula, under which a name was introduced by Clive in a way which law would not sanction, and the man in question threatened to disclose the whole plot to his master. When the life of a great man was written, the author suffered from the same fault from which Boswell suffered: he tried to glorify his hero at the expense of others, and Macaulay, forgetting that his hero was as much to be blamed as those who were parties to that secret compact, fell foul of the man because at the last moment he threatened to disclose the whole conspiracy against the Government of which he was a servant. Whatever might have been the rights and wrongs of that transaction, Bengalees had nothing whatever to do with it. The man was an adventurer,

a banya, who had come all the way from the Punjab to Bengal, and settled in the Court of Siraj-ud-Daula. His will had been discovered in the archives of the Supreme Court of Calcutta, and it had been clearly demonstrated that he had no Bengalee blood in him. Again, coming to the life of Warren Hastings, Macaulay brought his accusation against the Bengalee people, because Maharaja Nuncomar fought Warren Hastings with his own weapons. He did not wish to enter into the merits of the controversy, but Nuncomar was hanged for an offence for which at the present moment no man would suffer such a heavy punishment. The question whether Nuncomar was guilty of forging a document had been seriously doubted by learned historians, and the whole story had yet to be cleared up; but, nevertheless, Bengalees had suffered because of the accusations made against them by that brilliant writer of the nineteenth century. It was not until Europeans settled down in Bengal and knew the people at first hand that they began to realise that the first impressions they had received of the people from writings such as those he had referred to were not true. He desired to join issue with the statement made by Mr. Gourlay that the Bengalees had not displayed any warlike qualities in their character. It was true they were a very peaceful and peace-loving people, but it must not be forgotten that the histories to which the author had referred were written by those who came to Bengal as successful invaders. Stewart's history was based upon the story of a Mohammedan historian who treated the conquest of Bengal by Mohammedans in the twelfth century as a very easy affair, and the King of Bengal as a contemptible old man. Only the other day the German Kaiser spoke of the British Army as a "contemptible little army" because he believed he would win. He (Mr. Basu) read years ago the story of the Battle of Waterloo in a German history, and it was there narrated, for the edification of German students, that that great battle was won by General Blücher with the assistance of an English brigade under Wellington! It was the misfortune of the Bengalees that the histories available at the present time were not written by Bengalees, and a wrong perspective had therefore been given of Bengal history. The fact was that, when war broke out in 1914, the unwarlike Bengalees came forward and offered their services in any capacity to fight for the British. When, after long delays, permission was granted to their young men to form into volunteer corps throughout all India, Bengal was the Province which supplied the largest number of recruits from among its highest castes, and the sons of noblemen and gentlemen, nurtured in the lap of luxury, went to Mesopotamia at 11 rupees a month to fight the battles of the Empire. Their numbers, as gentlemen volunteers, exceeded those of all the other races of India. When Akbar, the great Mogul Emperor, established his sway over India, Bengal was the only Province which gave him much trouble to conquer. Twice the Mogul armies were defeated by Bengalee soldiers, and what the Moguls failed to obtain by fighting they obtained by treachery. The question might be asked why Bengalees had not written a history of Bengal. He frankly confessed that their ancestors, the Hindus of India, lacked the historical sense; but under modern education a class of men were growing up who would write such histories if proper encouragement was given to them. It was worth while, not only for the sake of the country, but even politically, to study the history of Bengal if it was desired to know the spirit of the Bengalee people. A very serious situation was at present being dealt with in Bengal, namely, the growth of anarchy. Many present would remember the tremendous excitement into which Bengal was thrown after the partition, when measures of repression were adopted. He was not ashamed to confess that he was in the forefront of the men who were opposed to that partition. When Sir Charles Bayley was appointed Lieutenant-Governor of the Eastern Province at Dacca for a short time, he won over the hearts of the people within the very few months he was there, and they became really afraid of his influence. The people thought he would spoil what they were trying to achieve. By means of kindness, sympathy, appreciation and consideration for the feelings of the Bengalee people, he was gradually winning them over to his side. Similar instances of the same kind were now occurring; there was great need for careful consideration of the many vexed questions that arose, and it was necessary that those who were charged with the administration of the Province should know something not of the wars of the conquest but of the people, and therefore a history of Bengal was an urgent necessity.

Sir Charles S. Bayley, G.C.I.E., K.C.S.I., in proposing a vote of thanks to the author for his most interesting paper, and also thanking Lord Carmichael for presiding over the meeting, endorsed the remarks that had been made by previous speakers that there was a great want of something in the nature of an accessible and readable history of Bengal, and he hoped the paper would be the means of forwarding the preparation of such a work. It had often occurred to him that the Government might with advantage set aside a certain amount for this and similar purposes, so that the Service might carry out work which could not be equally well done in any other way. There were large numbers of good collectors and good judges; but every now and then there was a brilliant genius of some sort who was neither the one nor the other, but who was very good at literature, science, philology, or some other subject outside his ordinary official duty, and who might be utilised for special purposes. He would like to see the Government set aside one appointment, say in the ranks of the collectors, in which a man could be employed to undertake the task which the author had indicated, or any other

special work which would benefit India. He thanked the Chairman for the very kind allusions he had made to his (the speaker's) efforts in the cause of archæology.

SIR HERBERT ROBERTS, Bt., in seconding the motion, thought that in the interests of Bengal itself and of this country it was most important that a connected history of the Province should be written. He had been for over a quarter of a century in the House of Commons, and he felt that one of the great needs of the present day, in view of the tremendous developments which lay ahead, was that the history of India should be better known to the people of this country.

The resolution of thanks was then put and carried, and MR. GOURLAY and the CHAIRMAN having briefly acknowledged the compliment, the meeting terminated.

NEW TUNNELLING SYSTEM.

There have lately been issued Letters Patent by the Governments of the Dominion of Canada and the United States covering a scheme for the driving of tunnels through soft and treacherous materials, by means of a machine which is a combination of the present type of shield and the hydraulic suction dredge.

This combination is made possible through the placing of a short concentric shield within the outer one at its forward end; this inner shield has longitudinal motion only, within the outer shield, while its forward end is closed with a revolving end or bulkhead, through which are passed one or more large pipe shafts, upon whose outer ends are fastened suction dredge cutter heads which have independent circular motion, and whose inner ends are connected to a manifold revolving with the end of the inner shield.

Means are provided for forcing water into the space in front of the shield, where it is maintained under a slight pressure, while an axially located discharge pipe, of sufficient size, is connected to the manifold, which permits the continuous removal of the material from the breast, which has been loosened by the cutter heads. This removal of the excavated material along with varying proportions of water, is effected by means of centrifugal pumps connected to the discharge pipe, which suck it through the cutters as it is loosened, and force it back through the discharge pipe to the portal of the tunnel.

The longitudinal motion of both shields is controlled by means of the ordinary hydraulic jack method.

By using this type of machine it is claimed that the use of compressed air is eliminated, except in cases where obstructions are encountered in conjunction with an excess of ground water; that the softer the material the greater the speed of the shield; that the cost of excavation and removal of the muck is reduced to practically the same basis as hydraulic suction dredging, and that all material from sand and muck to shale rock, can be handled successfully.

NOTES ON BOOKS.

FIREWOODS: THEIR PRODUCTION AND FUEL VALUE. By A. D. Webster. London: T. Fisher Unwin, Ltd. 12*s.* 6*d.* net.

The extreme coal shortage of this winter and the fear of a miners' strike have no doubt led to much greater attention being paid to the value of firewood. Previous to the war, of course, we had such cheap imported wood that there was an almost unlimited quantity of old boxes, rough ends, and waste from sawmills. That day, however, is past, as, with a much greater cost of imported timber generally, greater care is being exercised in its use, and even empty boxes command a comparatively high value. The author tells us the main sources of firewood are: (1) The "lop and top" as well as the stumps and roots of the trees of nearly a million acres; (2) hedgerow timber. These trees can be thinned out or, in some cases, pruned, with advantage to the agricultural or garden crops; (3) the old "stag-headed" and over-mature trees of garden and park.

From all these sources it is estimated that there are 2,000,000 tons of wood, suitable for burning, which could be obtained. It sounds very expensive to dig up the roots of trees to produce only firewood, but with blasting and with stump-pullers, the work is easily done. Incidentally, it improves the ground for planting. Then, too, there are some small circular saws, suitable for cutting up wood actually on the "felling" site.

Different woods have extraordinarily varying values for heating purposes. Hazel wood burns well; oak is very hard to beat, but the smoke irritates the throat; Lawson's cypress and cedar wood burn with a pleasant fragrance; properly seasoned, yew more nearly approaches to coal in its heating power. Generally speaking, it is safe to say that 2 to 2½ tons of wood are equal in heating power to one ton of coal. An interesting table of the firewood values is given of some thirty different kinds of the commoner woods. It will repay close study. Storage capacity is a difficulty in towns. Usually firewood is sold by the cord, which may weigh from 1½ to 2 tons, and will yield when cut up about 1,000 logs of the usual firewood size. A most readable chapter is devoted to charcoal wood. Here we have apparently a profitable local industry, especially that of growing alder buckthorn (*Rhamnus Frangula*), for the production of charcoal wood. It is the best of its kind, and yields 27 per cent. of charcoal, as compared with only 16 per cent. in the case of larch. Firewood grates are considered in a special chapter.

Manual of Electrical Undertakings and Directory of Officials. 1918–19. London: Electrical Press, Ltd. 22*s.* 6*d.* net.

This work, compiled under the direction of Mr. Emile Garcke, is Vol. XXII. of a series which has been issued annually since 1896. It consists of 1,677 pages—not including a mass of advertisements—and forms, with those volumes preceding it, a complete record and history of the electrical industry for the last twenty-two years.

A summary is given at the commencement of the volume of the various Parliamentary Reports and Bills, etc., which have been issued during the past years, together with statistical and other information.

The work is divided into sections. Section I., by far the larger portion of the volume, is devoted to a detailed account of municipal undertakings, public and private companies concerned in the supply of electric light, power, and traction, in the United Kingdom. Section II. contains a list of telegraph and telephone companies arranged in a similar manner to the previous section. In Section III. are given particulars of companies and firms connected with the manufacture and supply of electrical machinery and apparatus. Section IV. deals with electrical undertakings in the Colonies and foreign countries.

Following these sections is a very complete directory, giving the names, addresses, and official positions or occupations of persons connected with the electrical industry at home and abroad

GENERAL NOTES.

The Norwegian Iron Industry.—A fact to be reckoned with in the industrial reconstruction with which Europe is faced, according to the *Zeitschrift für angewandte Chemie*, is the rapid development of the Norwegian iron industry. The possession of almost unlimited water-power, with rich and extensive deposits of ore, gives Norway advantages which may ere long place her in the front rank of iron-producing countries. New projects show a determination to build up an industry which shall at least render Norway independent of foreign produce. The Government has encouraged schemes for immediate expansion, and will this year (1919) pay a premium on every ton of iron and steel produced. Several firms have taken up the production of cast-steel on a large scale. The Titan Company has begun the manufacture of ferro-manganese and of graphite crucibles. New iron and steel works are under consideration, and the erection of large wire-drawing works is a scheme likely soon to be realised.

Sisal in Florida.—A tract of land of 25,000 acres is to be utilised in Florida for the purpose of planting and exploiting sisal on a commercial basis. Already 1,000 acres of this land have been cleared, says the *Board of Trade Journal*, and 750,000 henequen plants are to be set out immediately. These plants were planted in the nursery about two years ago, and have now reached a height of 15 inches. In connection with this new industry for Florida, it is stated that in the autumn of 1921 the leaves will be cut from the plants and the fibre taken out in a decorticator, the plant and machinery of which will be the most modern procurable. The henequen plant is well adapted to Southern Florida, where the true sisal (*Agave Sisilana*) was introduced from Yucatan in 1826. Since that time the plant has been growing wild in certain parts of the State, but no effort has been made to exploit it until the present decision to cultivate it on a large scale. At the present time the United States imports over 600,000,000 lb. of sisal annually, costing the farmers over 100,000,000 dollars each year. Before the war sisal was sold in the United States at about 6 cents per lb., while to-day it is bringing 20 cents per lb. It is stated that each acre of land will produce about one ton of fibre, making returns of some 400 dollars per acre.

British Scientific Products Exhibition, 1919.—The British Scientific Products Exhibition, 1919, will be held at the Central Hall, Westminster, during the month of July. The British Science Guild has been encouraged to organise this Exhibition by the success which attended that held at King's College last summer and the more recent Exhibition at Manchester. Now that many inventions can be shown which could not be put before the public during the war, there is every prospect that this year's Exhibition will be even more successful than its predecessors. The objects of the Exhibition will be to illustrate recent progress in British science and invention, and to help the establishment and development of new British industries. Such an Exhibition will enable new appliances and devices to be displayed before a large public, and will provide progressive manufacturers with an opportunity of examining inventions likely to be of service to them, thus serving as a kind of clearing house for inventors and manufacturers, as well as illustrating developments in science and industry. The Exhibition will include sections dealing with chemistry, metallurgy, physics, agriculture and foods, mechanical and electrical engineering, education, paper, illustration and typography, medicine and surgery, fuels, aircraft and textiles. Firms desirous of exhibiting are invited to communicate with the Organising Secretary, Mr. F. S. Spiers, 82, Victoria Street, London, S.W. (1)

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

April 2.—W. Norman Boase, C.B.E., Chairman of the Flax Committee for Scotland, "The Cultivation and Preparation of Flax, and the

Linen Industry." SIR FRANK WARNER, K.B.E., President of the Textile Institute, will preside.

APRIL 9.—LEONARD ERSKINE HILL, M.B., F.R.S., Director, Department of Applied Physiology, Medical Research Committee, "Housing and Infant Mortality." SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., F.R.S., late President of the Royal College of Physicians, will preside.

APRIL 30.—SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 7.—JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 14.—H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m. :—

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

Dates to be hereafter announced :—

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

J. N. SPENCER WILLIAMS, "The Hawaiian Islands and their Industries."

SANDFORD J. KILBY, "Indian Salt Manufacture."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

The object of the course is to discuss present knowledge of foodstuffs—their character, functions and assimilation—and to consider the directions in which our dietetic policy is open to criticism and improvement and should be taken into account in determining agricultural practice and our economic policy. The effect of faulty feeding on public health will be specially considered; also the problem offered by vinous beverages.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 31...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor H. E. Armstrong, "Problems of Food and their connection with our Economic Policy." (Lecture I.)

Farmers' Club, 12, Great George-street, S.W., 4 p.m. Mr. V. A. Malcolmson, "The Economic Future of Agriculture."

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m. Mr. J. W. Hurrell, "Building Contracts before and after the War, and the Functions of the Quantity Surveyor."

Industrial Chemists, National Association of (London Section), at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Mr. S. R. Todd. "Government Reconstruction Committees and Industrial Chemists."

TUESDAY, APRIL 1...Technical Inspection Association, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C , 2.30 p.m.

Röntgen Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8.15 p.m. Dr. W. S. Lazarus-Barlow, "Some Biological Effects produced by Small Quantities of Radium."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Scotland." (Lecture III.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Labour Co-partnership Association, Kingsway Hall, Kingsway, W.C., 4.30 p.m. Paper on "The Printing Business of E. S. and A. Robinson."

WEDNESDAY, APRIL 2 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. W. N. Boase, "The Cultivation and Preparation of Flax, and the Linen Industry."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. C. Opperman, "Electric Vehicles."

Archaeological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. A. Vallance, "Building Materials and Local Conditions."

THURSDAY, APRIL 3...Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. W. B. Brierley, "An Albino Mutant of *Botrytis cinerea*." 2. Dr. J. D. F. Gilchrist, "The post-Puerulus Stage of *Jasus lalandii*." 3. Mr. M. Drummond, "The Ecology of a Small Area in Palestine."

Child Study Society, 90, Buckingham Palace-road, S.W., 6 p.m. Dr. E. Pritchard, "Home *v.* Institutional Training for Young Children."

Automobile Engineers, Institution of, Chamber of Commerce Hall, Birmingham, 7.30 p.m. Captain G. Smith-Clarke, "Some Notes on Petrol Flow-meters and the Calibration of Carburettor Jets."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Findlay, "Colloidal Matter and its Properties." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. Piper, "Amiens Cathedral."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Lieut.-Colonel A. G. T. Cusins, "The Development of Army Wireless during the War."

FRIDAY, APRIL 4...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor F. Harrison, "The History of the City of Constantinople."

Philological Society, University College, W.C., 5.30 p.m. Professor W. A. Craigie, "Dictionary Evening."

SATURDAY, APRIL 5...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Spectrum Analysis and its Application to Atomic Structure." (Lecture V.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish St. Clement Danes, in the City of Westminster.—March 28, 1919.

No. 3463. APRIL 4, 1919 Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,463. VOL. LXVII.

FRIDAY, APRIL 4, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 7th, at 4.30 p.m. (Cantor Lecture.) PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." (Lecture II.)

WEDNESDAY, APRIL 9th, at 4.30 p.m. (Ordinary Meeting.) LEONARD ERSKINE HILL, M.B., F.R.S., Director, Department of Applied Physiology, Medical Research Committee, "Housing and Infant Mortality." SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., F.R.S., late President of the Royal College of Physicians, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

EXAMINATIONS.

The number of entries received for the first examinations, which commence on the 7th inst., is 11,962. For the corresponding examinations last year there were 10,828 entries.

The second examinations commence on May 26th, and the last day for receiving entries is April 28th.

CANTOR LECTURE.

On Monday afternoon, March 31st, SIR JAMES CRICHTON-BROWNE, M.D., LL.D., F.R.S., in the chair, PROFESSOR HENRY E. ARMSTRONG, F.R.S., delivered the first lecture of his course on "Problems of Food and their Connection with our Economic Policy."

The lectures will be published in the *Journal* during the summer recess.

SIXTEENTH ORDINARY MEETING.

Wednesday, April 2nd, 1919; SIR FRANK WARNER, K.B.E., President of the Textile Institute, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Baria, Raja of (Captain His Highness Maharaol Shree Ranjitsinhji), Devgad Baria, India.
Bedford, Jesse, Wh.Ex., A.M.I.Mech.E., A.M.I.A.E., Chingford, Essex.
Fawcett, James W., Sheffield.
Garnett, Cecil Stevenson, Matlock.
Jackson, Captain Edward Almond, R.A.F., Doncaster.
Judge, Lieut. Arthur W., R.A.F., [illegible]Sc., Wh.Sc., A.M.I.A.E., Butley, Suffolk.
Rosling, Sir Edward, London.
Smith, T. Graves, M.I.Mech.E., Stonehouse, Gloucester.
Stone, Leslie Norman Waldegrave, Woolwich.

The following candidates were balloted for and duly elected Fellows of the Society:—

Carlyle, Sir Robert Warrand, K.C.S.I., C.I.E., London.
Cochran, A., Calcutta, India.
Davies, Walter, M.B.E., London.
Dhunjeebhoy, J. S., London.
Hooker, William Alfred, London.
Kesterton, Henry Martin, A.M.I.A.E., Birmingham.
Paton, James Wallace, J.P., Birkdale, Lancashire.
Royce, Frederick Henry, West Wittering, Sussex.

A paper on "Flax: its Cultivation, Preparation, Spinning, and Weaving," was read by Mr. W. NORMAN BOASE, C.B.E., Chairman of the Flax Committee for Scotland.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 12th, 1919; SIR ROBERT A. HADFIELD, Bt., D.Met., F.R.S., Vice-President of the Society, in the chair.

THE CHAIRMAN, in opening the meeting, said that the reader of the paper was connected with the Equipment and Engineering Company, by whom experiments were recently carried out for

him by Mr. Lorkin and Mr. Charles R. Darling, with reference to the welding of manganese steel. He believed the Admiralty had recently appointed an Electric Welding Research Committee, of which Mr. Charles R. Darling, of the City and Guilds Technical College, Finsbury, was chairman, and he heartily congratulated Mr. Darling on having been appointed to that important position. It was interesting to note that the subject of welding seemed to be assuming great importance at the present time, for many papers and discussions had taken place, of which he appended a bibliography [*see* p. 304]. He attached very great importance to the work being done in America, and congratulated our American cousins on the magnificent way in which they overcame the difficulties connected with repairing the damage inflicted on the German ships interned in American ports during the early stages of the war. Those ships, which were almost hopelessly wrecked by the Germans, were converted within a few months into valuable transport vessels, which conveyed hundreds of thousands of American soldiers to France, so that the Germans, with all their cleverness, were not able to prevent Americans rendering effective aid in the great war. In one of the papers above mentioned the praises of Germany were sung by the author, who stated that in that country they were far more advanced than Great Britain in the oxy-acetylene process, also that more systematic and exhaustive researches had been carried through—a statement with which he did not at all agree. Clever, however, as the Germans might have been, there was one important point in which they failed in their efforts to weld properly together—viz. the chain of the Hindenburg line. It was regrettable that more attention had not been paid to the study of welds in the production of steel bars by means of micro-structure examination. Without doubt that method would teach engineers very much, and improve the quality of work. It had already been done in a few cases with conspicuous success. He referred those interested to the very excellent paper read before the American Institute of Mining Engineers by Mr. S. W. Miller, on "Path of Rupture in Steel Fusion Welds." This paper entirely based its conclusions, and rightly so, upon some hundred or more micro-examinations of welded specimens. The importance of satisfactory welds was shown by the fact that it was proved that the serious breakdown of the Charing Cross Station building some years ago was found to be entirely due to a badly welded roof joint. It might prove to be the case that radiometallography would be found useful to determine the soundness of welds. The Faraday Society would hold a symposium on the important subject of radiometallography at the end of April in conjunction with the Röntgen Society, when very important contributions on the subject were expected from Professor W. H. Bragg and others; also valuable communications as to what was being done in America, Germany and elsewhere. It had often proved quite difficult to weld steel, but at the same time it was overlooked that such material generally contained manganese even in quite considerable percentages, for example up to 1 per cent. This metal, when present in the material known as steel, readily oxidised, and prevented satisfactory welding unless the operation was very carefully carried out. Moreover, ordinary steel was often high in the metalloids sulphur and phosphorus, both of which were deleterious to welding. That was why Swedish steel was better in that respect, because of its greater purity as regards sulphur and phosphorus contents. Another point which was often overlooked was that welding temperatures, being so high, were bad for steel, coarsening the grain and making the material brittle. Hence all welded materials should be carefully annealed, normalised, or heat-treated after welding. As a proof of the correctness of his remarks relative to the presence of manganese in iron and steel alloys, he desired to say that the peculiar steel alloy known as manganese steel, which he invented many years ago, and containing as it did some 12 per cent. of manganese, could not be satisfactorily welded, *i.e.* the welds were imperfect and of no real strength. He had never yet seen a perfect weld of manganese steel, for however good it might appear on the surface there were always cracks underneath due to the co-efficient of contraction and the embrittling action. In some experiments carried out for him by Mr. Charles R. Darling, samples of manganese steel were prepared in the shape of flat bars, about 3 in. in width and ½ in. in thickness. This material presented great difficulty in welding, no doubt owing to its peculiar composition, viz. about 1¼ per cent. carbon and 13 per cent. manganese. Into a standard type of tensile bar made of manganese steel, viz. having a distance between centres of 2 in. and ·798 in. diameter, was cut a V-nick running transversely about half way through the sectional area of the bar. This was then welded by Mr. W. L. Lorkin, of the Equipment and Engineering Company, the following being the results of the tensile tests obtained. Practically there was no weld except on the outer surface of the V-nick, and the tensile test gave the low figure of only 21·6 tons per square inch, and elongation practically nil. Attempts were also made to weld together flat plates of ordinary mild steel by means of manganese steel electrodes, the plates being 4 in. × 4 in. × ⅜ in. in thickness. The results were again negative. It was a singular fact that at one of the discussions he recently attended on electric welding, it was stated that considerable difficulty was experienced in welding copper because of the low resistance of the material. On the other hand, manganese steel, which offered very high resistance, presented an equally difficult problem, though of course owing to other causes. Much attention had been paid to the subject of welding in America. Several papers had been read before the American Institute of Mining Engineers,

one being on "Welding Mild Steel," by Mr. H. M. Hobart, the Chairman of the Welding Research Sub-Committee. His report was presented under the joint auspices of the National Research Council and the Emergency Fleet Corporation. A large number of experiments were carried out upon ship-plate steel having the following composition:—

	C.	Mn.	P.	S.	Si.
Maximum per cent.	·25	·46	·043	·031	·052
Minimum ,,	·24	·45	·039	·027	·024

The steel had been produced under Lloyd's Specification. The tensile strength allowed varied from about 25 tons up to 32 tons per square inch. Mr. H. Jasper Cox, of Lloyd's Register of Shipping, gave considerable help to the author in question. Experiments were carried out with regard to fusion welding, which term covered gas welding and electric arc welding. Gas welding was usually effected by simultaneously fusing with an oxy-acetylene flame: (1) the material at and near the surfaces which it was desired to join, and (2) some material (which was usually similar in composition) in the form of a rod, the tip of which was subjected to the heat of the flame. The oxy-acetylene flame was directed with one hand and the welding rod was manipulated with the other hand. Electric arc welding might be subdivided into several classes: (*a*) Carbon arc welding, (*b*) Metal arc welding. The former used graphite electrodes, and the latter metallic electrodes. There was also a method known as spot welding, which had been used largely in ship construction. This consisted in bringing into good contact, by hydraulic or pneumatic pressure, overlapping portions of the plates or parts requiring to be joined, and in sending through the spot of contact a sufficiently large current to heat the plates or parts at that point to a welding temperature. The weld was effected by the combination of pressure and heat. A full description of spot welding and spot welders was given in the four following papers in the *General Electric Review* (December, 1918): (*a*) "Research in Spot Welding of Heavy Plates," by W. L. Merrill; (*b*) "Spot Welding and Some of its Applications to Ship Construction," by H. A. Winne; (*c*) "An Electrically welded Freight Car," by J. A. Osborne; (*d*) "Some Recent Developments in Machine for Electric Spot Welding as a Substitute for Riveting," by J. M. Wood. It was not for him to go into details as to the amount of electric energy consumed, as that was fully described in Mr. Hobart's valuable paper before mentioned. Mr. Hobart's conclusions were that fusion welding was by far the best method, also that whilst sound and quite ductile welds could be depended upon for plates of not over about ½ in. in thickness, the results were not so good with plates of greater thickness. It had now been conclusively shown that stronger and more ductile welds ½ in. in thickness were obtained by using at least 200 amperes, also that fully 300 amperes should be used for butt welding ¾ in. plates, and at least 400 amperes for 1 in. plates. To show the complexity of this apparently at first sight somewhat simple matter, Mr. Hobart in his paper gives no less than thirty-four points for discussion, including amongst others: composition of metal deposited in weld; polarity; direct current versus alternating current for arc welding; comparative quality of arc welds made with alternating current and with direct current; respective fields of gas and arc welding; suitable current for given cases; and technique of testing welds. Referring again to the valuable paper which was recently read before the American Institute of Mining Engineers on "Path of Rupture in Steel Fusion Welds," by Mr. S. W. Miller, of the Rochester Welding Works, N.Y., Mr. Miller pointed out that trouble was often met with in regard to brittle welds, and he considered the only way to account for that brittleness of welds was to assume that it was caused by films of material at the grain boundaries, the nature of these films differing in different welds. In a specimen made by the carbon arc process there was one spot where the original material was melted down and decarburised by the heat, in which there were very faint films round the grain. These films were evidently cementite trapped at the grain boundaries by the rapid cooling. They were 0·00002 in. thick in places, and in spots where they could not be seen it seemed entirely reasonable to suppose that they existed, but were ultra-microscopic. Mr. Miller added that it would not seem probable that in the metallic electrode welds such films would be of cementite, as the carbon was almost entirely burned out; they might be nitride of iron. It was also possible that, as Humfrey suggested, they were oxide of iron. In one of his figures he showed comparatively thick films of iron oxide in an oxy-acetylene weld, in which there were nests of these films in many places. Evidently crystallisation could not proceed through these films, whatever their nature, nor did it seem possible that amorphous material could exist there. It was quite probable that where the films were cementite they could be absorbed by heat treatment. This could occur when the films were nitride of iron, and probably was impossible when they were oxide of iron. It seemed quite plausible that these films could be of ultra-microscopic thickness; and, as all of them were brittle, they would be very weak under shock, and probably under alternating stress, although their thinness might account for the high tensile strength of the welds in which they existed, on the same principle that a thin film of glue was stronger than a thick one. Metal electrode welds had sometimes a tensile strength as great as 70,000 lb. per square inch (49·19 kilogrammes per square millimetre), and would probably have this always if they were sound. Oxy-acetylene welds made with low carbon material had much greater ductility and resistance to shock because of the absence of these films; and it appeared probable that within limits the purer the material the more ductile such a weld would be. Whilst Mr. Miller questioned whether anything had been noticed confirming the belief in the presence of these films, there would seem to be no reason to doubt their existence, and Mr. Miller fully believed they were

mainly responsible for the brittleness of such welds. He appended the following short bibliography relating to welding, as it occurred to him that those interested in the matter might like to see the various papers which had been presented, especially during the last four or five years:—

ELECTRIC WELDING.—BIBLIOGRAPHY.

Date.	Title.	Author.	Publication.	Country.	Description.
1914 Feb. 20	Some Modern Methods of Welding	Thomas T. Heaton	Institution of Mechanical Engineers	Great Britain	Paper.
1918 May 16	Electric Welding for Ships under Test on Large Scale	. . . .	"Engineering News Record"		
	Some Notes on Modern Methods of Electric Welding, and their application	H. S. Marquand.			
	Welding and Cutting Metals	Dr. L. A. Groth.			
	Welding	Richard N. Hart			
	Bibliography of Electric Welding	Wm. F. Jacob	"General Electric Review"	United States	
Sep. 16	Electric Welding: a New Industry	H. A. Horner	American Institution of Electrical Engineers	United States	
Nov. 8	Welded Ships	Wm. Shenstrom	"Electrician"	Great Britain	
Nov. 15	Electric Welding	Thomas T. Heaton	Institution of Mechanical Engineers	Great Britain	Paper
Nov. 27	Notes on Regulations for Arc Welding	H. M. Sayers	Institution of Electrical Engineers	Great Britain	Paper.
Dec. 26	Welding on Iron and Steel	W. H. Cathcart	"Iron Age"	United States	Article.
1919 Jan. 24	The Development of the Oxy-Acetylene Welding and Cutting Industry in the United States	Henry Cave	Institution of Mechanical Engineers	Great Britain	Paper.
Jan. 31	Electric and Oxy-Acetylene Welding	. . . .	"Engineering"	Great Britain	Cutting.
Feb.	Oxy-Acetylene Welding	J. H. Davies	Institution of Mechanical Engineers	Great Britain	Paper.
Feb.	Oxy-Acetylene Welding	F. Hazledine	Institution of Mechanical Engineers	Great Britain	Paper.
Feb.	Path of Rupture in Steel Fusion Welds	S. W. Miller	American Institution of Mining Engineers	United States	Paper.
Feb. 14	Electric Welding and Welding Appliances (1)	. . . .	"Engineer"	Great Britain	Article.
Feb.	Welding Mild Steel	H. M. Hobart	American Institution of Mining Engineers	United States	Paper.
Feb. 21	Electric Welding and Welding Appliances (2)	. . . .	"Engineer"	Great Britain	Article.
Feb. 28	Electric and Acetylene Welding	. . . .	"Engineering"	Great Britain	Article.
Feb. 28	Electric Welding and Welding Appliances (3)	. . . .	"Engineer"	Great Britain	Article.
Feb. 28	Electric Welding Problems	. . . .	"Engineer"	Great Britain	Article.
Mar. 11	Experiments on the Application of Electric Welding to Large Structures	W. S. Abell	Institution of Civil Engineers	Great Britain	Paper.
Mar.	Electric Welding Developments in Great Britain and the United States of America	James Caldwell and H. B. Sayers	Institution of Civil Engineers	Great Britain	Paper.
Mar.	The Application of Electric Welding in Ship Construction and Repairs	H. R. Smith	Institution of Civil Engineers	Great Britain	Paper.

The paper read was—

ELECTRIC WELDING AND ITS APPLICATIONS.

By WALTER LEONARD LORKIN, A.M.I.E.E.

INTRODUCTION.

Electric arc welding passed out of the experimental stage into the practical stage many years ago, but, in spite of this fact, the subject is still rather vague to many people. It plays an important part to-day in the manufacture and repair of many articles. Some have hesitated to adopt the process, because they failed to see its advantages and doubted its efficiency. They did not appreciate that, by installing a small electric plant, they had at their disposal a ready means of carrying out work which had previously been beyond their power. They further, no doubt, thought that the plant and apparatus employed were complicated, and required extreme skill in handling, and probably thought that the amount of benefit gained would not be sufficient to justify the original outlay.

The object of this paper is to show to engineers and others that the process is simple, that it can be carried out with ordinary labour, and that the welds are efficient and effected at small cost.

In miscellaneous shop repairs the cost of welding ranges from one to ten per cent. of the value of the article repaired.

Within the last few years, and especially during the great war, apparatus for electric welding has been perfected, and such enormous strides have been made in application and use that it is undesirable to attempt to define limits to the adoption of this process.

Electric welding covers a number of distinct operations. It is advisable, consequently, for the clear understanding of this subject, to consider the process from the standpoint of pressure or resistance welding, spot welding, and autogeneous or fusion welding. The following will outline some of the plants in use, and the work which has actually been carried out.

The pressure or resistance method of welding was invented by Elihu Thompson, and commercially produced about 1880. Resistance, pressure, or contact butt welding, is an operation where two pieces of metal are brought to the plastic state by passing a heavy current of electricity across an imperfect contact, when, by means of pressure, the weld is effected. The parts are placed in position so that, the welding temperature being reached, consequent increased pressure establishes their union; the weld is generally hammered during cooling. The system is commercially successful, and has been largely used in the production of many parts for years past. In order to obtain the large amount of current which is required effectively to weld even small pieces, it is usual to employ an alternating current transformer. This is incorporated in a special machine, which consists of a clamping device, by which the heated surfaces may be brought together directly they are raised to the correct welding temperature. The transformer is of the ordinary double-wound type, having a primary winding suitable for the supply voltage and periodicity of the circuit, whilst the secondary is a single turn, and is usually in the form of a large copper or bronze casting. The current produced in the latter has, generally, only a pressure of a few volts, whilst the current may be many thousands of amperes. As this high current cannot be conveniently carried for any distance, it is usual to form a clamp for holding the work directly upon the ends of the secondary winding, so that the circuit may be as short as possible. To deal with the many shapes of commercial parts, the welding apparatus must consequently be designed for the various demands.

Slide No. 1 shows one of the most popular of these designs, employed in the joining of bars end to end. The clamps are fitted upon the bars about 3 in. away from where the union has to be effected; the hand lever is then applied, thus bringing into contact the two surfaces to be joined. The current is then switched on to the primary of the transformer, and the heat consequently generated at the contact softens the metal. Further pressure, applied by means of the hand lever, causes the two surfaces effectively to weld together, and to form a bulge round the joint. The current is then switched off, and the work removed. In the larger sizes of these machines the pressure is applied by hydraulic means, and the electrodes, or clamp ends, are often water-cooled, to prevent their heating up through continuous use.

Slide No. 2 shows another and larger machine, having a capacity of 60 to 100 kilowatts, capable of joining bars up to half an inch or more in thickness. The electrodes in this case are very massive castings, water-cooled, and the pressure is applied by hydraulic means.

Electric Spot Welding.

A development of this process is known as spot welding, and its particular application is for the joining of thin metal sheets, wires or plates together, by means of a series of spot welds, thus replacing riveting.

Slide No. 3 shows a machine specially designed for this purpose. The operator places the metal sheets upon the table over the lower or stationary electrode so that the overlap or joint occurs in the correct position. He then brings the upper electrode down upon the work at the spot where the weld is required. Heat is at once generated, and the two plates are pressed together by means of the upper electrode. The pressure is then released and the sheets moved into the position for the next spot weld. Under this system it is possible to produce as many as six or eight spot welds per minute, according to the thickness of the plates and the character of the work.

The method may also be applied to seam welding, in which case the pressure and current are conveyed to the point of operation through the medium of rollers.

An illustration of this work is seen in welding the seam of a tube. In that case the tube passes between the rollers, and is subjected to an indefinite and continuous number of spot welds establishing a perfect union.

To meet the supply conditions for the resistance of pressure process of welding, alternating current must be used. Where direct current only exists it is thus necessary to convert this into alternating current by means of a motor-driven alternator.

Amongst the various industries to which the pressure or resistance method of welding can be applied are the following: The manufacture of hollow metalware; the joining of agricultural implement parts; the welding of tube seams and tube lengths.

The system has also been applied to the welding of rail ends. Slide No. 4 shows a machine for this work. The machine employed in this case is shaped like a large inverted U, carried above the rails by means of a crane.

Autogeneous or Fusion Welding.

Autogeneous welding is performed in either of the two following ways: By the employment of the carbon arc; by the employment of metallic electrodes.

Requirements of the Arc.

It is well known that an arc is formed by touching two contacts or poles of an electrical supply circuit, and withdrawing them slightly. An arc is thus established which, in burning, consumes the electrodes. The temperature of an electric arc is the highest known, exceeding 3650° Centigrade. The positive pole is about 1000° in excess of the negative. At the moment of striking the arc a virtual so-called short circuit is formed, which permits a rush of current far exceeding that afterwards consumed in the arc. This high-value current would, uncontrolled, produce evil effects, such as the melting of fuses, the opening of circuit breakers, besides imposing great strain upon the generating plant. Therefore, it is necessary to introduce some means which will prevent this, or at all events limit it to reasonable values. This can be carried out by various methods, which will be enumerated. The best known and perhaps most widely-used method is to insert in the circuit an amount of resistance which will only allow the current to rise to a safe value upon striking the arc. Unfortunately, the resistance has to remain in the circuit the whole of the time the arc is working, and wastes a considerable amount of energy by converting it into useless heat. The amount of resistance is governed by a law relating to the permissible rise of current at the arc. Fifty per cent. is about the highest value which can safely be used, and this entails that approximately the same amount of energy should be consumed in the resistance as in the arc. As the arc voltage is about 25, the supply should have sufficient pressure to equal this and that consumed in the resistance. With the 50 per cent. rise named, 25 volts must be the pressure across the resistance, so that the supply pressure will not be less than 50. Where higher voltages are used (and there are many cases in actual working) the loss in the resistance, or stabiliser as it is often called, is even greater, and may be twice and even three times that consumed in the arc. The author has found many cases where 110 volts are used, and in several instances 200 and even 210 volts. As only 25 volts are used in the arc, it is apparent that the remainder are absorbed in the huge resistance and dissipated as useless heat. Obviously, if we are to work economically, we should employ the lowest line voltage at which we can carry out efficient work. This loss, or inefficiency in arc welding, is a serious feature, but it can be obviated, as will be demonstrated later in the paper.

The Voltage of the Welding Arc.

The voltage between a ferrous metal electrode and the iron or steel operated upon, will be found generally to vary from 18 to 25 volts. The variation is due to the operators, who hold different lengths of arc, according to their individual methods of working. Twenty-five volts is the most common figure, although many of the best workers prefer to retain the arc at 23. To draw an arc over 27 volts results in bad work; flaming occurs, and there is the liability of bubbling in the molten metal.

The lowest voltage at which the arc can be maintained for any length of time is about 18, but its employment depends upon the character of the metal forming the electrode and the flux, as a softer metal or ferrous alloy will vaporise at lower temperatures, and furnish conductive gases, thus allowing the arc to be established at lower voltages.

In the alternating current arc the author has found the voltage across the arc to be slightly higher. This is probably due to the fact that it is impossible to hold a short arc, owing to the peculiar way in which the metal falls in globules

from the electrode. The voltage, therefore, with alternating current is about 30 volts, although it is continually fluctuating as the globules form and fall. It is well known, however, as shown by the investigations of the late W. E. Duddell and others, that the electrical arc, by its rapid variations of resistances, produces oscillation effects at a very high frequency.

Slide No. 5 shows one of the E. & E. electrodes at work on mild steel plate, on a direct current circuit. Slide No. 6 illustrates an electric arc, taken on alternating-current circuit, with a similar electrode. You will notice two bands of light across this picture, one above and the other below the arc. These bands are repeated again at other regular intervals, and the author has found them on all the photographs of alternating arcs. It is a matter for further investigation as to whether the speed of the shutter and exposure agree with the periodicity of the alternating-current circuit in any respect, or whether these bands can be accounted for in any other manner.

Carbon Arc Welding.

Electric welding, using the carbon arc, is the older of the two main systems in autogeneous welding, and was originated by Benardos over thirty years ago. In this system, graphite carbon electrodes are used, and they vary from ¼ in. to 1½ in. in diameter, and from 6 in. to 12 in. or more in length. They are pointed so as to focus the work as much as possible. The sizes vary according to the class of work to be done. The carbon is mounted in a suitable holder, and it is attached to the negative pole of the supply, the positive being attached to the work. It is very important to observe that this polarity is maintained correctly, as if it is reversed molecules of carbon will be conveyed from the electrode to the work, and incorporated in the newly deposited metal, rendering it very brittle and difficult to machine subsequently.

The process of carbon arc welding is employed for the filling of holes in castings and in the cutting of metals. The carbon arc in such cases supplies the heat, the filling metal being provided by a metal bar fed into the arc. Slide No. 7 shows an operator at work with this process. With the carbon arc it is necessary to have 45 volts or more, and from 100 to upwards of 600 amperes, the variation being decided by the class of work and speed at which the operation is to be conducted.

Carbon arc welding has its own particular sphere. It is especially suitable for rectifying steel or malleable iron castings rendered defective through the presence of blowholes and other imperfections. It has also the power of washing out sand from internal hollows and replacing it with new metal, applied from a wrought-iron bar in the other hand of the operator. When skilfully done, these blowholes can be so filled up that no trace remains. The value of carbon arc welding in the foundry is thus evident; an imperfect casting is no longer food for the scrap-heap, but is an object to be perfected. Another advantage is that holes can be quickly produced in iron or steel plate by holding the arc over the spot until the metal melts right through. Thus it forms a quick and cheap substitute for rough drilling.

Carbon arc welding has also been applied to the manufacture of steel barrels, consisting of a cylindrical drum, hooped and with cup-shaped ends. When these are correctly situated on the ends of the barrel, the carbon arc is played over the edges all the way round, with the result that the hoops and the sheet metal are effectively welded together. This process of barrel manufacture is largely employed, and is commercially a success.

The repair of holes worn oval in machinery is another sphere for the employment of the carbon arc; and Slide No. 8 shows a tramcar part, with such a hole. In the centre, the oval hole is filled in with new metal, and on the right we have a hole re-drilled to the correct size. Thus, by this means many parts which would otherwise have to be scrapped can be reclaimed and used again. In the tramway and railway world there is much work of this character to be done, and here the importance of electric arc welding cannot be overestimated. Slide No. 9 shows an operator effecting repairs to tramway rail-joints. Cylinders of engines, which to replace new would cost anything from £150 to £300, can be restored to service at a cost which is insignificant in comparison. Broken engine frames are frequently welded in place, and miscellaneous lugs and brackets, including those on air pumps, are also restored by this means. So fully is the value of electric welding appreciated by the author, that he is confident each railway and tramway depot will have its own separate and complete plant installed, ready for instant repairs.

Electric Bonding of Rail-joints.

Another field for the use of the carbon arc is in copper bonding of rails for electric traction

purposes. The welding of bonds across rail-joints is an American feature. Slide No. 10 shows a copper bond, of large section, fitted to a conductor rail of an electric railway system. The bond itself consists of laminated copper strips. The carbon arc, directed upon the ends of the copper strips, melts them down, and welds the copper bond to the steel rail. Further supplies of copper can be fed in from a copper melt bar, held in the left hand of the operator. By this process, the molten copper is burnt into the edge of the rail. The same process is then repeated at the other end of the bond, thus forming a solid copper weld at the edge of the rail.

There is an enormous advantage in this system of bonding. The ordinary method of attaching bonds entails drilling holes in the rail and fitting the ends of the bonds with taper pins, driven in from the other side. Bonds thus fixed are liable to work loose under traffic conditions, the connection is consequently imperfect, and a dangerous fault in the system arises. With the electrically-welded bond this danger is entirely absent, as perfect electrical connection is made, and the necessity of drilling holes is avoided. Not only is there a great saving in labour by this process, but there is also the saving of energy otherwise lost in defective rail circuits.

Cutting Metals by the Carbon Arc Process.

The carbon arc process is also largely used for the cutting of metals; but the work performed is not as neat as that done with an oxy-acetylene blow-pipe. This is due to the fact that the arc oscillates from one side to the other, thus melting the adjoining edges of the metal. The actual cutting is accomplished more quickly with the electric arc when dealing with metal up to 1¼ in. in thickness. Its value in cutting up scrap metal and in demolition work is thus evident.

When metal cutting is contemplated the supply should be capable of carrying from 400 to 600 amperes, although it is possible to do effective work at a lower current. It is also desirable to have a direct current supply for the carbon arc process.

The current taken by the carbon arc is usually far higher than that consumed when using metallic electrodes. For ordinary filling of small holes of about 1 in. in diameter the current may be 150 to 300 amperes, while for cutting it should be not less than 400 amperes, as stated above. The cutting of metal up to 1¼ in. can be carried out at a very much lower cost than by the oxy-acetylene process, and on thin plates the difference is nearly 50 per cent. in favour of electric cutting.

The rays from these large carbon arcs are very harmful to the eyes and skin, and special precaution must be taken by the operator to guard against them playing upon any unprotected part. This matter will be considered at a later stage, under the heading "Operators' Protective Gear."

Metallic Electrodes.

Metallic electrodes are a comparatively recent introduction in electric arc welding, and apparently were originated by Slavinoff in the year 1895. Here the necessary filling metal is supplied by the metallic electrodes themselves as they melt, and this simplification of the process of welding indexes an important advance. This stage, however, was not final. The rapid cooling of the metal from the electrodes, coupled with a considerable amount of oxidisation, tends to make the deposit brittle and spongy. This immediately suggested that some form of flux was necessary to assist the process of fusion. Kjellberg, about 1897, introduced a flux for metallic electrodes, and later Mr. Strominger, of London, developed an electrode already fluxed. Various fluxes have, from time to time, been developed and can be applied either by laying them upon the work during the process of welding, or coating the electrode itself with the flux material. The latter has found preference, mainly because the right amount of flux is conveyed to the arc as the welding proceeds. These fluxes generally consist of silicates, the fusing point of which is high and which, as heat-resisting agents, furnish a desirable coating over the newly deposited metal.

Coated electrodes have now become a commercial article with a competitive market. They are sold in bundles, ready for use, in various gauges.

Electric welding is very similar to oxy-acetylene welding, in that a V groove is formed at the joint, into which the metal is deposited. Slide No. 11 shows a plain butt joint, V'd both sides, with the metal deposited, the black portions showing the latter. It will be noticed that there is a resulting increased thickness of the plate where the weld occurs. This is considered a permissible feature in welding, and enables the original strength of the plate to be maintained. By piling up the metal in the manner shown, the strength of the weld

can be made greater than that of the plate itself. Slide No. 12 shows an angle joint constructed in a similar manner. It will be seen that the plates automatically form a V groove of 90°, without any special preparation, suitable for depositing metal into.

It is essential that the edges of the plates, before welding, do not meet, otherwise the newly-deposited metal will not pass through to the other side.

Slide No. 13 shows a lap-joint welded at both the upper and lower edges of the seam. This joint is commonly used in ship construction, and has the advantage that it caulks the joint automatically at the same time.

These three joints are typical of the great majority of work carried out, but many other types will, no doubt, be suggested.

Another feature of the metallic electrode is that it is possible to weld vertical and even overhead seams. Both these processes, however, are slower, and require more skill than downward welding.

In welding with metallic electrodes, a certain amount of carbon is lost during the process; therefore the percentage of carbon in the deposited metal will not be so high as that originally existing in the electrode itself. It has even been contended that the deposited metal is entirely free from carbon; that, however, is a fallacy.

It is difficult to weld with a high-carbon steel electrode, unless other constituents are present, and apparently no advantage is gained by attempting to do this. It is, however, possible to use electrodes having other ingredients which, by their high-fusion point, are enabled to pass through the arc and into the work. A particular case in point is a steel having a high manganese content, commercially known as "Hadfield's steel." When electrodes formed of this metal are used, the deposit can be so hard that it cannot be attacked by a file, and can only be dressed by grinding. These electrodes are used for particular purposes, such as the renewal of lips on dredger buckets, the renewal of wearing surfaces on rumbles of dredgers, and the filling in of worn hammered depressions upon rail-ends, where the drop of the vehicle wheel occurs.

Further, the deposit from these electrodes has the property of being non-magnetic, which renders it useful for certain electrical surfaces.

Another material which can be embodied in the electrode is silica. Silicated electrodes give a deposit nearly akin to ordinary cast-iron, of a brittle nature, and with a contraction point very similar to that of cast-iron itself; consequently there is less internal stress resulting from cooling. The ingredients of the flux, and its thickness of coating upon the electrode, are varied with the different circumstances covering the contents of the steel, and its particular purpose.

The author has confined the above remarks to metal electrodes for dealing with ferrous metals only. The question of electric welding of other metals is largely in the experimental stage. He is already able to state, however, that some early progress is expected in this direction. Of copper welding, the easiest of these problems, an illustration has already been given in the treating of bonding upon rails.

Alternating current can be used, but it has the disadvantage that the process is not so effective, and the arc is considerably more difficult to handle, especially at low voltages.

Welding can be carried out with metallic electrodes in almost any desired direction. The majority of work, however, is in a plain downward direction, such as the flat seam upon a plain surface.

Slide No. 14 shows an operator welding downwards. This is the easiest method of welding, as gravity helps to retain the molten metal in position.

Slide No. 15 shows the operator at work on a vertical seam. This is more difficult than downward welding, and the process is slower. The operation is started at the bottom of the seam, and the metal gradually built up. The deposited metal is frequently hammered to consolidate it and give a better appearance.

Slide No. 16 shows the operation of overhead welding. This is the most difficult of all positions, and needs expert skill. The making of vertical and overhead welds is largely a matter of experience, and an expert operator will so play his arc that the metal has time partly to set. It is impossible in overhead welding to do so neat work as when the welding is downward. Considerable hammering and caulking is necessary to consolidate the metal and to remove the globules which remain, due to the action of gravity, when the metal is in a semi-molten state. It is, however, quite possible to make satisfactory overhead welds, a number of examples of which, together with others, are on the table before you.

Slide No. 17 shows a view of a deposit given by a bare electrode, and the peculiar mushroom formation, due to the cooling action of the air,

will be noticed at the sides. There are times, however, when such a deposit is desirable. Yet the majority of cases require that the edges of the deposited metal shall present no abrupt termination as here shown.

The use of the flux was early seen to be necessary, as this covers the deposited metal with a hard silicate scale, and prevents too rapid cooling. Further, by preventing free access of oxygen to the metal, oxydisation and imprisoned air-bubbles are avoided. The use of the flux also assists the operator in maintaining his arc, as ingredients can be incorporated in the flux, such as aluminium or magnesium, which will give conductive gas, and thus reduce the resistance of the arc.

Various substances are used for these fluxes, the composition of which has been dictated by experience, and the recipes are more or less trade secrets of the various manufacturers. One of the most frequently used fluxes is asbestos, which, together with other silicate compounds, is coated over the rods. The standard length of electrodes, settled at 18 in., is about as long as can conveniently be handled. Various gauges are supplied to suit different size work; the current taken by the arc varies with the size of the electrode. In practice, metallic electrodes require a current varying from 35 to 180 amperes.

A successful electric weld with metallic electrodes, should withstand a tensile test equal to 90 per cent. of the original strength of the plate operated upon. Most of the experiments carried out by the author have been on steel plates of 26 to 30 tons tensile strength, and tensile tests as high as 27½ tons in the deposited metal have been obtained. Of course, it is desirable to know the elongation, hardness, the ultimate tensile strength, and the results of bending and vibration tests. In this connection, the Marine Department of Messrs. Lloyd's have recently introduced certain regulations which give their requirements of welding tests in connection with ship construction. The Marine Department of the Board of Trade has also recently consented to the repair of boiler shells by electric welding, under certain conditions. This Department is careful to stipulate, however, that no welding shall be done to these parts by any process which may cause local heating over an appreciable area of the plate, such as would occur with oxy-acetylene, oxy-hydrogen, or other similar methods. After repairs by electric welding have been completed, the parts at, or adjacent to the welds should, in all cases, be well hammer-tested, and, unless the welding is of a trivial character, a hydraulic test should follow, of not less than twice the working pressure of the boiler.

The application of electric welding to shipbuilding is very important, both as an addition and also as a substitute to riveting. Vessels have already been built, and others are in course of construction, of from 5,000 to 7,000 tons capacity, at the yards of Messrs. Cammell Laird and Messrs. Swan Hunter and Wigan Richardson. The first ocean-going rivetless barge was constructed at Richborough, Kent, and has been in continuous service for some considerable time. Pontoons and seaplane lighters have also been constructed with success without rivets, the air-chambers of the latter having to withstand a hydraulic test of high intensity.

In connection with the joining of plates upon a ship's side, it has the great advantage that it performs the dual operation of riveting and caulking. Joints formed in this manner further have the advantage that sea-water does not have free entry to the interior of the lap-joint, thus preventing corrosion and prolonging the life of the ship. It is estimated that the time for construction will be considerably accelerated by the use of electric welding.

Alternating Current.

The facilities which exist for the transmission and transformation of alternating current would imply that this current is particularly suitable for welding work. The fact that the current can be conducted to the location of welding operations by small wires conveying current at high voltage, and there converted by means of static transformers to a pressure suitable for the welding arc, infers the great advantage to be derived. A disadvantage, however, is found in the arc itself, which is not so stable at low voltage, and cannot be so easily handled as the direct current arc. Upon touching the electrode upon the work, to strike the arc, there is a very distinct tendency for the electrode to cling to the work, unless a high-line voltage is used. This tendency is also apparent with direct current, but to a much smaller extent.

This matter is now being investigated by many workers, one theory being that a local condenser effect with an oscillatory discharge occurs at the moment of striking the arc, and produces heavy local currents which cause the electrode to adhere. This theory is supported by the fact that it is far easier to strike an arc

upon metal which has already got a slight silicate coating over it than upon clean new metal. The added resistance, due to this silicate coating, prevents these local currents forming.

Further, alternating current is not so efficient as direct current. The voltage between the electrode and the work is nearer 30 than 25, and it is necessary to have a considerable reserve of voltage in the supply circuit to maintain the arc.

During the whole process of welding with alternating current, the electrode holder vibrates, and this is extremely enervating when welding is carried on continuously. The arc is also far noisier in action. Neither is it so suitable for overhead welding, which can be carried out most efficiently with direct current. Alternating current cannot be used satisfactorily for carbon arc welding, owing to the fact that the carbon is carried from the electrode into the welded metal, producing brittleness and hard surfaces.

Operator's Protective Gear.

During the process of welding by the arc method it is very necessary for the operator thoroughly to protect his eyes and all parts of the body from the injurious rays of the arc. This is more important when using the carbon arc than when using metallic electrodes. Much has been written and said about electric arc welding being classified as a dangerous trade. This, however, is grossly unfair, as many other trades are just as dangerous, and it is only necessary to exercise due care to avoid injury.

The welding arc is particularly rich in ultra-violet and infra-red rays, which are invisible. Therefore the operator must use screens or glasses for viewing the arc, suitable for counteracting the effect of both these sets of rays and for reducing the intensity of the light. Much investigation has been centred on this matter, but the author has found that one of the best combinations used is a special green glass combined with a deep ruby. These two glasses, however, being too transparent in themselves, a third must be added—a smoked glass, varying in depth of tint to suit the operator's choice. This triple set can be mounted either in a head or hand screen. In the hand screen the triple glass combination is mounted upon the metal work, but evidently this hand screen can only be used at such time as the operator has one hand free to hold it. The head screen, however, allows full freedom to the operator in the use of both his hands, such as the holding and manipulation of a melt bar or hammer. It is fitted to the head by means of metal bands, the weight being taken upon the chest of the operator. It is also necessary that the operator should wear suitable clothing to secure immunity from the burning sparks, or stray scraps of metal which fly about during welding. A leather or asbestos apron and also a pair of gloves, together with the face or head screen above referred to, afford every protection for all ordinary purposes in downward welding. For overhead welding, the author advises additional combination asbestos sleeves and mittens and an asbestos hood.

If the electric arc should accidentally be observed with the naked eye, the painful effects are not immediately felt, but may occur some hours afterwards, generally during the evening or night following the day on which the accident occurred. The pain is often very great and the smarting eyes continuously water. It can, however, be mitigated by bathing the eyes in cold water, and is over as a rule in a few hours. The skin also, if exposed, is subject to ill effects in the form of eruption of the pores and often of painful sores, especially when the carbon arc is employed. Carelessness here brings a punishment which engenders future care. It is also necessary to guard anyone who may be a voluntary or involuntary spectator of welding work. The operation should always be surrounded by screens, so that the rays may not affect neighbouring workers. The Home Office are issuing regulations to deal with arc welding work of this nature, and special provisions to secure the immunity of neighbouring workers or chance spectators from hurt will be framed.

Types of Supply and Generating Plant.

Electric current for welding can be drawn from any suitable supply, providing it is ample to meet the demands, and is of the correct voltage. Very few public supply undertakings will permit current to be drawn from their mains for direct use in an arc for welding purposes. As the current is usually 100 amperes and upwards, the sudden demand of the welder would submit a strain upon any system to the detriment of other neighbouring consumers. Another drawback is that practical welding work often requires one pole to be earthed, and as large masses of work (boilers, for instance) cannot be effectively insulated from the ground, such earthing would not be allowed by the supply

company. Where, however, a transformer or motor generator is imposed between the supply and the arc an amount of flexibility which eradicates or smooths out the erratic demands of the welder is thus secured which removes the trouble due to earthing. Further, few supply companies furnish current at a voltage lower than 200. This would entail great loss in the current-limiting resistance or stabiliser above referred to. Current, however, can be taken from the consumer's own generator, which should be wound to give a voltage of 60, to enable the arc to be efficiently supplied. Such machines can be made to feed any number of welding arcs in parallel, and may be driven by any form of steam or internal-combustion engine. The engine, however, of whatever type, should have sufficient fly-wheel effect, and should be fitted with a sensitive governor.

The welding generator should be evenly compounded. The welding load is, perhaps, the worst form of load which the generating engineer has to cope with. It is worse, in fact, than many traction loads, and the plant, therefore, must be constructed of such a type as will meet these extraordinary demands. An ordinary dynamo of the type to meet a lighting load would be quite unsuitable for welding purposes, owing to the fact that it is not designed to withstand the enormous strains imposed upon it. A shunt-wound dynamo is obviously unsuitable, owing to the severe dropping characteristic, and the nature of demand, for, upon striking the arc, there is obviously a heavy rush of current, which brings the voltage to a very low point, from which it has to be built up again for the welding current. Where such a machine has already been put down erroneously for welding work, the fitting of a separate exciter will, to a large extent, establish its suitability.

Motor-driven Generators.

Where the electric supply has to be transformed for direct current welding work, the following converting apparatus may be considered under these headings:—

A. Taper or parallel path resistance.

B. Rotary convertors.

C. Double-wound armature machines.

D. Plain motor generators with fixed couplings.

E. Motor generators, reducer balancer sets.

F. Motor generators, with magnetic automatic slipping clutches.

The majority of the above are so well known that the author only proposes to touch upon A. and F.

A. Where the voltage of the circuit is consistent at 60 or 110 volts, a resistance is necessary to limit the current in the manner above described. Usually there are two types of resistances or stabilisers in use:—

1. The taper type of resistance, consisting of a single circuit throughout the resistance. The section of the resistance conductor gradually tapers towards one end, in proportion to the reduction of the current, as extra resistance is thrown in. Tappings throughout the length of the resistance are conveniently situated in the form of terminals, to which connection can be made.

2. The resistance known as the parallel path type, consists of a number of resistance units, arranged in paths, each path passing a definite amount of current. For instance, one path might pass 50 amperes, another 25 amperes, another 15 amperes, another 10 amperes. A resistance on this principle is shown in Slide No. 18. Each path is controlled by a switch, and by making combinations of the different paths practically any current value can be obtained.

F. Motor Generators, with Magnetic Automatic Slipping Clutches.

This is a recent development of a motor generator, having an automatic slipping clutch, or magnetic coupling, which is differentially wound. This clutch is the invention of Messrs. W. L. Davies and A. Soames, and is called the "Daysohms." The great advantage of this clutch is that the use of the current limiting resistance is entirely avoided.

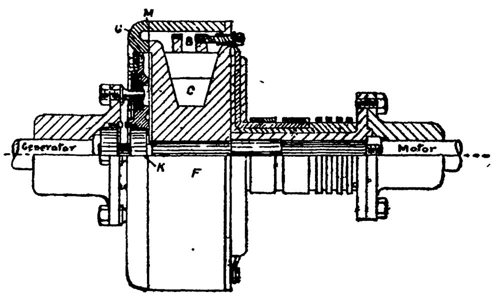


Fig. 1.—Section of Clutch.

Slide No. 19 (Fig. 1) shows a section of the clutch. The motor, or driving end, is on the right and carries the body of the clutch. This is really a rotating pot form of magnet, having the poles at point M. G is the yoke which is supported on a driving plate mounted on a radial ball-

bearing, K. The dynamo shaft on the left carries a coupling, with pins, engaging in bushed holes in the driving plate, and also another ball-bearing to support the weight of the body, F. The energising coils are situated at A, B, and C. A is the main magnetising coil of fine wire, energised from some convenient constant potential source, such as the motor-driving supply, and magnetising the clutch in a direction which we will call positive. A is a few turns of heavy copper strip, carrying the whole of the welding current, and magnetising in the opposite direction to A, or negative. C is another fine wire coil which is connected as a shunt across the dynamo terminals. This is also connected in a negative sense, so that B and C tend to operate against, or weaken the flux due to A. Upon starting the machine, coil A is energised so that the clutch revolves as a solid piece, and with the dynamo exciting (it is separately excited from the motor supply) coil C comes into operation, weakening the clutch hold to a certain degree.

Upon striking the arc, current flows through coil B, and if the current exceeds a certain amount, the combined effort of B and C will neutralise the flux due to A, and the clutch will slip.

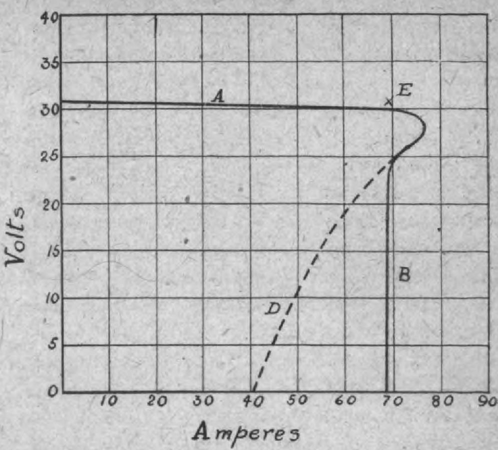


FIG. 2.—CHARACTERISTIC CURVE OF GENERATOR FITTED WITH MAGNETIC CLUTCH.

dynamo speed falls, owing to the slip, its volts descend, and the effect of coil C in its demagnetising properties becomes less. This is equivalent to strengthening the flux due to A and allowing the clutch to regain its hold, so that the current falls down the vertical line. E is the point of operation, so that no slip occurs, except upon the operator shortening his arc, or otherwise raising the current.

The nose seen in the curve is of great advan-

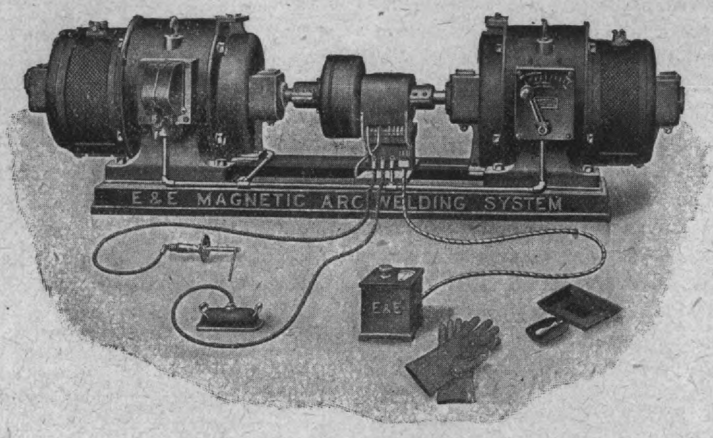


FIG. 3.—MOTOR GENERATOR WITH CLUTCH FITTED.

Slide No. 20 (Fig. 2) shows the characteristic curve of a machine bearing this device. It will be seen that the current here rises to 70 amperes, at which the clutch is set slip.

Owing to the peculiar behaviour of the law governing the co-efficient of friction, the clutch would hold on too long, and on slipping the power would fall right off, the current descending down the dotted line D. It is here that the advantage of coil C is evident, for, as the

tage in working, as it enables the operator to strike the arc with ease. By means of small rheostats, the currents in coils A and C and their consequent magnetic effects can be varied, thus giving the operator a considerable range in current values.

Slide No. 21 (Fig. 3) shows a motor generator, arranged for welding, with the clutch fitted. The small box seen in the foreground contains the regulating rheostats for controlling the

clutch excitation, which box the operator keeps by his side while at work, so that he can vary the current according to requirements. The motor side of the equipment can be made for any suitable supply. Where the supply is alternating, an induction motor is used, and a small separate exciter must be provided, to excite the generator and the A coil of the clutch.

These clutch machines only supply one arc each. They, however, form convenient small units, which can be mounted upon a hand-drawn truck and drawn about a works or shipyard. Each has its own switch-gear, directly attached, and this is of the simplest description. No fuses are fitted in the welding circuit, none being required.

A reversing switch is provided, so that the polarity of the welding circuit can be reversed at will.

One Large Generator Versus Small Single Units.

Obviously, welding generators can be made in any suitable size for the supply of any number of welding arcs upon a constant voltage system. Before doing so, however, it will be well to consider the question of distribution and location of all the welding operators concerned. Where a number of operators are grouped together in one workshop, it would obviously be cheaper to put down one generator, which would supply current to them all, for the reason that the copper mains supplying the large currents involved would not be very extensive, and might consist of copper bars placed along the walls, from which each operator would draw his own current by means of cable tappings. Where, however, welding operators are spread over a large area, such as, for instance, in a shipyard or large works, the question of distribution of large currents may become a serious obstacle. With the low voltage involved, namely 60, it is very easy to incur serious potential drops unless ample allowance in copper is made. Further, there is the feature that the mains would have to be carried to every part of the works, and certain portions of them might not be used for long periods. Therefore, such outlay of capital would be unremunerative. Another defect which is very apparent is that one welder, in one portion of the yard, might connect one pole of the system to earth; at the same time another operator, working in another portion of the yard, might do the same thing, but with the reverse pole. Obviously, such a proceeding would result in a short circuit upon the whole system of distribution. These facts show up the defects of a large low-voltage service of distribution, and enhance the value of a distribution of high-voltage mains, of small section, throughout the yard, terminating in suitable connection-boxes located at convenient spots.

Small motor-generators, such as those embodying the magnetic clutch, which the author has already described, and having motors suitable for a high-voltage supply, would be carried upon hand-drawn trucks to the neighbourhood of the welding work, and there connected to the nearest box. A plant thus mounted is shown in Slide No. 22. By this means any welder would be absolutely independent of the other, and could reverse the polarity of his current without interfering with anybody else's supply. The capital outlay for such a system of small machines, whilst being more than the single generator system, would not be prohibitive. The mains could be conveniently carried overhead upon poles, and even if situated in a portion of the works where welding was not often carried out, the loss in unremunerative outlay would not be great.

Another advantage is that small motor generator units could be increased as the demand for welding advanced. Such generators fitted with magnetic clutches, and capable of carrying a current of 120 amperes would form light and portable sets suitable for the purpose. For tramway and railway work the generators can be mounted upon trucks or repair cars to run on the track. A plant arranged thus is shown in Slide No. 23.

The author has arranged for a short demonstration of electric welding to take place after the discussion, if time permits.

The whole of the apparatus and accessories on view were manufactured at the works of the Equipment & Engineering Co., and the examples of welds were made by their own operators. The specimens of spot welding, however, were kindly lent by Messrs. The Electric Welding Co., Ltd., and Messrs. The A. I. Manufacturing Co. The author has also to thank Messrs. Davies & Soames for permission to include a description of the "Daysohms" clutch, which is incorporated in the "magnetic arc welding system" as made by the Equipment & Engineering Co.

[During the reading of the paper the chair was vacated by Sir Robert Hadfield and taken for the remainder of the meeting by Sir Frank Warner, K.B.E.]

DISCUSSION.

MR. G. F. CRAVEN, in opening the discussion, said the paper was necessarily of a general character. It would have been more interesting to him if more detail had been given of electric welding in connection with tramways and railway work, of which the author had had considerable experience. Work connected with tramways and railways was becoming of considerable importance at the present time. The Southampton Corporation tramways had made some headway both in the repairs of their cars and of the track by means of welding. The building up of rail-joints and similar work was likely considerably to increase the efficiency of tramways generally. He thought the oxy-acetylene process of cutting was far preferable to cutting by the carbon arc; it gave a cleaner job, although probably it was slightly more expensive. The authors of the large number of papers that had recently been read on the subject of electric welding were by no means unanimous in their conclusions. It seemed to be generally conceded that the welded joint was very efficient from the point of view of strength up to the elastic limit, but the requisite elongation and reduction of area were not obtained on the various tests; neither would an electric weld stand the repeated vibrations and bending that ordinary metal would. It seemed also to be generally conceded that the joint itself, whatever the composition of the electrode happened to be, resulted in iron, or something very closely approximating to pure iron. One did not get the carbon into the joint, as was very advisable in most cases, but probably research work would help in that respect. The author seemed to have obtained a certain number of results in connection with the welding of Hadfield's manganese steel. Although the welding electrode used apparently did not affect the hardness of the manganese steel, he desired to point out that even in welding manganese steel by the oxy-acetylene process, in which no special electrode was used, a similar hardness might be obtained even when using iron, so that the hard structure obtained by the author might not be due to the electrode at all. He desired to congratulate the author on his work in connection with the making of protective gear for welding. The specimens that had been exhibited showed that great progress in that direction had been made, as was very essential. The magnetic clutch machine was likely to prove a very serviceable article, inasmuch as it increased the over-all efficiency of welding considerably, avoiding the losses which usually had to be faced in connection with cumbersome resistances. He had seen the machine at work on several occasions, and thought there was a great future before it.

MR. W. T. ROBSON said that, like the last speaker, he was able to discuss the paper only from the tramway point of view. He was sorry that Sir Robert Hadfield had been obliged to leave the meeting, as he desired to mention a few points in connection with manganese steel. Manganese steel points and crossings in the past possessed the defect that they went spongy at the end, and until electric welding was used, that sponginess was a constant source of annoyance and expense. If Sir Robert would visit Southampton he would find that that trouble had been entirely overcome by the use of electric welding, and no difficulty was now experienced in correcting the spongy ends. One of the ordinary electrodes was used for the purpose, not a manganese electrode, and it was found that the fusion of the metal was particularly good, probably owing to the fact that a manganese electrode was not used. The manganese was not hard and brittle after the weld, as Sir Robert had stated. He thought the author was heartily to be congratulated on the work he had done in connection with protective devices. Those who began welding without much experience suffered greatly from it at the beginning. Personally he lay awake for the best part of one night in the greatest agony through going too near a carbon arc with about 300 amperes behind it, and the protective screens designed by the author would prove of great service to those unacquainted with the effects of carbon arcs particularly. Like the last speaker, he was not at all sure that it was best to use the electric arc for cutting purposes. It was very useful a year or two ago, when oxygen or carbide could not be obtained, but now that they were available again he thought most practical men would return to the oxy-acetelyne method for cutting, because it was much neater.

MR. HENRY B. SAYERS said that he was the Hon. Secretary of the Admiralty Committee of which Mr. Darling was the Chairman, and he wished Sir Robert Hadfield had included the other members of the Committee in the reference he had made, because they had done most useful work and had received no sort of remuneration for their services. The industry in general had been rather inclined to overlook the Committee, which he thought ought to have been supported more generally. The author had made some interesting remarks about arc voltage, and thought a benefit would be gained by lowering the main voltage from 100 volts, which was commonly used, to 60 volts, and much credit was due to him for being the first exponent of the theory that a large amount of power was being wasted, and that the voltage could quite easily be reduced without decreasing the efficiency of the weld. The author did not mention that one of the great benefits of lowering the voltage was that it acted as a safeguard against the welder making too long an arc, because directly the welder did so the arc vanished. He was sorry also the author did not refer to a series of tests that had been made, which showed very clearly that the tensile and the bending properties of the weld made with the low voltage were distinctly

better than those made with the high voltage, and led to a great deal of power economy. In referring to copper welding, the author had not referred to any other process than the carbon arc, but it was perfectly well known that it was possible to weld very successfully with a copper electrode, using the metal electrode system, with the electrode made of bronze instead of steel. There was only one point in the paper on which he did not agree with the author, namely, the statement that alternating current was not so efficient as direct current for welding purposes. He did not know whether the author had any figures to support that statement, but he suggested that some points of considerable importance must have been overlooked. He agreed with the author that with an alternating current, in order to maintain the arc a slightly increased pressure must be used at the generating terminals, so that there was more wasted energy in the form of heat. On the other hand, static transformers could be used with alternating current to reduce the pressure from the mains; there was considerable copper economy in distribution, and the static transformer was only working when the secondary circuit was closed. When a welder was on a job he was maintaining the arc only 50 per cent. of the time he was working; if he was using a generator set for the purpose, it was running constantly and consuming power all the time, and if alternating current was used those losses were got rid of at once. He thought if the author worked the figures out he would find it was not correct to say that alternating current was not so efficient as direct current. He desired also to emphasise the remarks made by the last two speakers in regard to the credit due to the author for his work on protective appliances. A slightly tinted glass was now available which did not impede vision in any way, and which absolutely screened the eye from any ultra-violet and infra-red rays. By wearing that glass as a simple spectacle an operator was absolutely safe from the flash of the weld. A welder or inspector of welds could wear a pair of such glasses the whole day without trouble at all, and would never suffer from that very painful complaint, arc eye. With regard to the carbon content of welded metal, the statement had been made that the carbon absolutely vanished from the electrode when a weld was made. There was a specimen on the table of a motor-car cam-shaft which suffered very badly from worn cams. The cams were built up with a metal electrode and then ground to size, and several similar shafts had been in use for many months. If a chemical examination were made it would be found that there was over 1·5 per cent. carbon in the deposited metal, so that he did not think it was right to say that it was impossible to deposit a carbon steel with an electric arc. As a matter of fact there was no limit to the amount that could be deposited in the way of alloy steels, either tensile or high speed, and that made the repair of crank-shafts, gear-wheels and pinions a very easy matter by that process.

On the motion of the CHAIRMAN, a vote of thanks was accorded to Mr. Lorkin for his interesting and instructive paper.

MR. W. L. LORKIN, in reply, said that Mr. Craven and Mr. Robson were quite correct in saying that the oxy-acetylene process possessed an advantage in the cutting of steel plates, etc., and he stated so in his paper; but there were many occasions on which rough cutting was required when the work could be done much more quickly and cheaply with the carbon arc. With reference to Mr. Robson's remarks on manganese steel deposits, he thought Sir Robert Hadfield referred more to the tensile stress than to wearing tests. He thought Sir Robert agreed that manganese deposits could be added to certain machine parts, so that greater wear could be obtained, but the tensile strength up to the present had been on the poor side. It was no doubt an advantage to have a low arc voltage, and an operator was naturally warned when he drew a long arc because the arc went out. If he had an open circuit voltage of 110 he could draw long arcs up to twenty-seven and thirty, which produced very bad work. The copper bonding of rails could be effected quite easily by using a copper electrode, as Mr. Sayers suggested, but he did not agree with the statement that bronze could be used. Pure copper and not an alloy must be used in the electrode. The advantage of alternating current over direct current, or *vice versâ*, was still a very difficult question to decide. Personally he thought direct current was more economical, firstly, because it gave a lower arc voltage, and, secondly, because there was a lower line voltage. He was very pleased to hear that a glass had at last been discovered which prevented the ultra-violet and infra-red rays from affecting the eyes and skin. He thought he was right in saying that up to the present a glass sufficiently clear had not been produced which enabled the operator to see the object to be welded, and at the same time gave sufficient protection to the eyes and skin. The cam-shaft referred to by Mr. Sayers was certainly a fine piece of work, and he thought if Mr. Sayers read the paper again he would see the statement was not made that the carbon disappeared in passing through the arc. He was very careful to say that there was a carbon deposit. A high carbon electrode could be used, but he thought he was right in saying that other steel constituents were necessary to ensure perfect work.

MR. CHARLES R. DARLING writes:—Mr. Lorkin's paper comes at a time when welding is the most prominent topic in engineering circles, both in this country and in America. Many papers have been read on electric welding during the past few months, most of which have been highly technical in character; and a general description of the whole subject, such as that provided by Mr. Lorkin, will be welcomed by all those interested in the

subject. It might be interesting to explain how the present "boom" in welding—and particularly arc welding—has arisen. Prior to the war, a fair amount of progress had been made, and arc welding was coming into use for repairs on ships, locomotives, etc. During the first three years of the war continuous progress was made, both in equipment and practice, one prominent feature being the introduction of the coated or fluxed electrode, which facilitated the ease with which welds could be made. In 1917, owing to the shortage of materials for oxy-acetylene welding, Major Caldwell was appointed by the Admiralty to investigate the possibilities of electric welding, and was able to show that the process possessed many unsuspected advantages. It was then realised by British and American engineers that they had ready to hand a method of construction capable of very great development, and experiments were immediately planned in both countries. A strong research committee was set up in America in 1918, and still continues its activities under the chairmanship of Mr. H. M. Hobart. A few months later a similar research committee was formed by the British Admiralty, with the present writer as chairman; but early in the present year the Admiralty relinquished its control, with the result that the operations of the Committee are entirely suspended for lack of funds. Considering the possibilities of electric welding in expediting the production of ships, it is deplorable that the work of the Committee should be held up at the present juncture, when it is most urgently needed. Amongst the debateable points raised by Mr. Lorkin's paper is the question of the fluxed electrode, the points in favour of which he has enumerated, and which is almost universally used in British practice. In America, however, it is claimed that quite satisfactory welding can be accomplished with bare electrodes, provided they be of correct composition, thus effecting a considerable saving in cost. This is a matter which requires careful investigation, and was one regarding which the research committee had planned a complete series of tests. Another point is the question of voltage. In many equipments a voltage of 100 or more was provided, although, as shown in the paper, only about 25 is needed at the arc. It was imagined that the surplus voltage had some beneficial influence on the weld; but as the recent experiments of Caldwell and Sayers show, no benefit accrues from providing more than 70 volts—thus vindicating Mr. Lorkin, who has consistently advocated the lower voltage. The question of the best welding current is still an open one, the trend of opinion in America being that high currents—150 amperes or more—give the best welds. In this connection Dr. J. H. Paterson, a member of the British Committee, has shown that up to 140 amperes the amount of metal deposited per minute rises uniformly, but afterwards diminishes; the weld, moreover, contains a minimum of oxygen when deposited with 140 amperes current. Here again full investigation is needed, so that welding outfits may be constructed so as to give the best results. The full possibilities of alternating current welding also require to be examined. When these problems have been successfully solved, the rapid progress of electric welding in many directions may be safely predicted.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m. :—

April 9.—Leonard Erskine Hill, M.B., F.R.S., Director, Department of Applied Physiology, Medical Research Committee, "Housing and Infant Mortality." Sir Thomas Barlow, Bt., K.C.V.O., M.D., F.R.S., late President of the Royal College of Physicians, will preside.

April 30.—Sir Herbert Jackson, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems." Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside.

May 7.—John Somerville Highfield, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside.

May 14.—H. Kelway-Bamber, M.V.O., "Railway Transport in the United Kingdom."

Indian Section.

Thursday afternoon, at 4.30 p.m. :—

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies as affecting Growth and the Value of Crops in India and other parts of the Empire."

Dates to be hereafter announced :—

Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Design in Japanese Art."

Brigadier-General Lord Montagu of Beaulieu, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

J. N. Spencer Williams, "The Hawaiian Islands and their Industries."

Sandford J. Kilby, "Indian Salt Manufacture."

Cantor Lectures.

Monday afternoons, at 4.30 p.m.

Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." Three Lectures.

March 31, April 7 and 14.

The object of the course is to discuss present knowledge of foodstuffs—their character, functions and assimilation—and to consider the directions in which our dietetic policy is open to criticism and

improvement and should be taken into account in determining agricultural practice and our economic policy. The effect of faulty feeding on public health will be specially considered; also the problem offered by vinous beverages.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 7... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Dr. H. E. Armstrong, "Problems of Food and their connection with our Economic Policy." (Lecture II.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5 p.m. Professor J. Young, "Modern Explosives."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. E. A. Alliott, "Drying by Heat in conjunction with Mechanical Agitation and Spreading." 2. Messrs. P. E. Spielmann and F. B. Jones, "The Estimation of Carbon Disulphide. A critical Examination of the various methods usually employed." 3. Messrs. P. E. Spielmann and S. P. Schotz, "The Estimation of Thiophene." 4. Messrs. P. E. Spielmann and H. Wood, "The Estimation of 'Free Carbon' in Tar and Pitch."

Geographical Society, Burlington-gardens, W., 8 p.m. Miss Czaplicka, "Poland."

TUESDAY, APRIL 8...Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Discussion on "Light and Colour in relation to Stage Production."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Wales." (Lecture IV.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Mr. G. Hughes, "The Electrical and Mechanical Equipment of the All-Metal Cars of the Manchester-Bury Section, Lancashire and Yorkshire Railway." 2. Mr. F. E. Gobey, "All-Metal Passenger Cars for British Railways."

Photographic Society, 35, Russell-square, W.C., 7 p.m. Discussion on the formation of a Technical and Scientific Group in the Society.

Anthropological Institute, 50, Great Russell-street, W.C., 5 p.m. Lieutenant E. W. P. Chinnery, "Reactions of Certain New Guinea Primitive People to Government Control."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Dr. F. E. Beddard, "Exhibition of, with remarks on, three fœtal Sperm-Whales." 2. Mr. L. T. Hogben, "The Progressive Reduction of the Jugal in the Mammalia." 3. Mr. G. A. Boulenger, "Description of Two new Lizards and a new Frog from the Andes of Colombia."

Colonial Institute, Central Hall, Westminster, S.W., 8 p.m. Lord Leverhulme, "British Traits and Ideals in relation to our Colonial Development."

WEDNESDAY, APRIL 9 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. L. E. Hill, "Housing and Infant Mortality."

Naval Architects, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 11 a.m. 1. Address by the President, the Earl of Durham. 2. Sir P. Watts, "Ships of the British Navy on August 4th, 1914, and Some Matters of Interest in Connection with their Production." 3. Sir E. H. Tennyson d'Eyncourt, "Naval Construction during the War." 4. Mr. S. V. Goodall, "The Naval Construction Corps of the United States Navy."

Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Lieut.-Colonel H. G. Lyons, "The Supply of Meteorological Information for Aeronautical Purposes."

Geological Society, Burlington House, W., 5.30 p.m. 1. Mr. W. Whitaker, "The Section at Worms Heath (Surrey), with Remarks on Tertiary Pebble-Beds and on Clay-with-Flints." 2. Mr. G. M. Davies, "Petrological Notes on the Beds at Worms Heath."

Labour Co-partnership Association, Kingsway Hall, Kingsway, W.C., 4.30 p.m. Right Hon. C. W. Bowerman, "A Combination of Trades Unionism and Co-partnership. The Co-operation Printers."

Engineers in Charge, Association of, St. Bride Institute, Bride-lane, E.C., 7.30 p.m. Sir Wilfred Stokes, "The Relationship between Wages, Output, and Improved Standards of Living from a practical Point of View."

Japan Society, 20, Hanover-square, W., 4.30 p.m. Miss J. M. Richardson, "English Ideas in Japanese Education."

THURSDAY, APRIL 10... Naval Architects, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 11 a.m. 1. Mr. A. E. Seaton, "The Work of the British Marine Engineering Design and Construction Committee." 2. Signor S. Orlando, "Italian Two-Floodable Compartment Cargo Steamers Built during the War." 3. Sir E. H. Tennyson d'Eyncourt and Mr. T. Graham, "Some Recent Developments towards a Simplification of Merchant Ship Construction."

3 p.m. 1. Mr. C. I. R. Campbell, "Development of Airship Construction." 2. Mr. W. L. Scott, "Concrete Shipbuilding in the United States of America."

7.30 p.m. 1. Hon. Sir C. A. Parsons and Mr. S. S. Cook, "Investigation into the Causes of Corrosion and Erosion of Propellers." 2. Mr. J. H. Gibson, "The Michell Thrust Block."

Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Findlay, "Colloidal Matter and its Properties." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. T. Manley, "Demonstration of the Ozobrome Process."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. R. J. Kaula, "Notes on Surface Condensing Plants, with special reference to the requirements of Large Power Stations."

Historical Society, 22, Russell-square, W.C., 5 p.m. Professor R. A. Gregory, "Science in the History of Civilisation."

FRIDAY, APRIL 11...Naval Architects, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 11 a.m. 1. Mr. W. H. Gard, "Some Experiences with Electric Welding in Warships." 2. Dr. J. Montgomerie, "Further Experiments on the Stress Determination in Flat Steel Plates." 3. Mr. A. T. Wall, "The Tonnage of Modern Steamships."

3 p.m. 1. Mr. J. L. Kent, "Model Experiments on the Effect of Beam on the Resistance of Mercantile Ship Forms." 2. Mr. J. Semple, "Some Experiments on Full Cargo Ship Models."

Pottery and Glass Trades' Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Institution, Albemarle-street, W., 5.30 p.m. Professor Sir J. J. Thomson, "Piezo Electricity and its Applications."

Astronomical Society, Burlington House, W., 5 p.m.

Engineers, Junior Institution of, 39, Victoria-street, S.W., 7.30 p.m. Mr. F. H. Taylor, "The Training of the Disabled Man from the Electrical Engineer's Point of View."

SATURDAY, APRIL 12...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Spectrum Analysis and its Applications to Atomic Structure." (Lecture VI.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—April 4, 1919.

No. 3464. APRIL 11, 1919 Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, at the Society's House, John Street, Adelphi, London, W.C. (1)

Journal of the Royal Society of Arts.

No. 3,464. VOL. LXVII.

FRIDAY, APRIL 11, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 14th, at 4.30 p.m. (Cantor Lecture.) PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Problems of Food and their Connection with our Economic Policy." (Lecture III.)

Further arrangements were announced last week.

CANTOR LECTURE.

On Monday afternoon, April 7th, DR. M. O. FORSTER, F.R.S., in the chair, PROFESSOR HENRY E. ARMSTRONG, F.R.S., delivered the second lecture of his course on "Problems of Food and their Connection with our Economic Policy."

The lectures will be published in the *Journal* during the summer recess.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 9th, 1919; SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., D.Sc., F.R.S., late President of the Royal College of Physicians, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Allen, Robert, M.A., B.Sc., M.Inst.M.M., Guildford, Surrey.
Bales, F. George, A.M.I.Mech.E., A.M.I.A.E., London.
Curr, Thomas, O.B.E., A.M.I.Mech.E., London.
Gedge, Ernest, F.R.G.S., London.
Giblett, Major Robert Harold, R.A.S.C., France.
Nancollas, Henry Philip, Llanelly.
Orme, Reginald Thomas, Derby.
Poulton, Captain Faville Clement, C.E., A.M.I.E.E., Stirling, N.B.
Ramsey, Arthur George, B.Sc., A.M.Inst.C.E., A.M.I.E.E., London.
Sarabhai, Ambalal, Ahmedabad, India.

The following candidates were balloted for and duly elected Fellows of the Society:—

Batliwala, Dr. S. S., L.M. & S., J.P., Bombay, India.
Bond, E., London.
Burbury, Henry Herbert Taylor, J.P., Wakefield.
Crowe, W. M., London.
Hall, Benjamin James, Eastcote, Middlesex.
Hogg, Malcolm Nicholson, Bombay, India.
Johnston, Major Cecil Hugh Ralli, R.A.F., A.M.Inst.A.E., London.
Murdoch, Richard Alexander, Bombay, India.
Taylor, Robert, Oldham, Lancashire.

A paper on "Housing and Infant Mortality" was read by DR. LEONARD ERSKINE HILL, F.R.S., Director of the Department of Applied Physiology, Medical Research Committee.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on March 13th, 1919; SIR CHARLES C. MCLEOD in the chair.

The paper read was—

THE REPORT OF THE INDIAN INDUSTRIAL COMMISSION.

By D. T. CHADWICK, I.C.S.,
Indian Trade Commissioner.

The report of this Commission is one that has been awaited with eager interest by very many in India. I am sure that all wish one of its members could have been here to deal with it. It covers a wide field, and advocates many changes. We are all living in days of change. Movements which, before the war, were gathering force are rapidly taking form and demanding decisions—decisions profoundly affecting alike

both the individual and State policy. India has not been exempt therefrom. Steamships, education, newspapers, telegraphs, and Japan have all combined to render no longer applicable to India the epithet of "the unchanging East."

Amongst other movements, the last twenty years have witnessed the growth of a belief widespread through the different classes, and often seeking vague, partial and hesitating expression, that industrial development and change in India were both possible and necessary for the general welfare of the country. In competent business circles there has recently been a breaking away from traditional lines of Indian industrial effort, viz. textiles, leather and mining. New ventures have been successfully inaugurated, such as steel and cement works, the application of electricity to industry, whilst at the other end of the scale are to be found some agriculturists who use internal-combustion engines to raise water, or who have invested money in rice-hulling plant, or joined together to erect a co-operative bone-crushing factory. There have also been many failures and partial successes, due at times to insufficient preliminary inquiries or deficient management, or to any of the hundred and one difficulties which beset the path of the over-confident pioneer; but all these were efforts to broaden the field of industrial activity. Local governments, responding to the spirit of the times, have also felt the need of a wider basis of employment, and have endeavoured to help the movement by revising constantly the syllabus of studies at technical schools, by occasionally engaging experts, and even at times by actually pioneering, testing, and founding new industries. There were, however, no settled broad lines of general policy, and the Orders of the Secretary of State in 1910 and 1912, while restricting in certain directions these official feelers after industrial development, seemed to have left local governments in doubt as to what extent and in what form they could give direct assistance to industrial effort. Moreover, these bodies had neither the organisation nor equipment to give expression to their desire to help.

Thus in 1916 there was a large body of public and official opinion in India not content with existing industrial conditions, and looking to Government for a declaration of its policy, and for an ordered scheme of action. A strong Commission, whose *personnel* is well known to many here, was then appointed under Sir Thomas Holland to report—

"1. Whether new openings for the profitable employment of Indian capital in commerce and industry can be indicated.

2. Whether and, if so, in what manner Government can usefully give direct encouragement to industrial development:—

(*a*) By rendering technical advice more freely available;

(*b*) By the demonstration of the practical possibility on a commercial scale of particular industries;

(*c*) By affording, directly or indirectly, financial assistance to industrial enterprises; or

(*d*) By any other means which are not incompatible with the existing fiscal policy of the Government of India."

We have to remember to-day that the events of the last two years have brought into glaring relief many of India's industrial deficiencies, have called forth more varied industrial efforts, and have greatly intensified the belief in, and the need of, Indian industrial development. As pointed out in the *Times* Trade Supplement of this month, such development is not necessarily antagonistic to British industries and commerce. Increased productive power will mean increasing needs and increased purchasing power. If India is to advance, it is necessary that the basis of employment of her people be widened, her economic efforts better balanced, and her ability to meet her most urgent needs in years of stress increased.

In answer to the first question in the reference the Commission find that India is, on the whole, not generally deficient in raw materials for industry, but in some particulars the supplies are not over-abundant or the location not very favourable, and in regard to others the work which has been done upon them is often insufficient to form the basis for immediate commercial or industrial action. The vital importance of agriculture to India is insisted upon. The results which have recently been obtained through the various agricultural departments are recognised, but the pressing need for more staff, better research, and more demonstration work is emphasised, not only for increasing the yield of crops per acre, but also for greater concentration of effort on crops such as cotton and sugar-cane, etc., which afford products suitable for local manufacture, and which are, therefore, potential creators of wealth for other classes than the agriculturist. By making agriculture more efficient in its processes a greater range of raw materials will become available to the industrialist, and some share

of that labour will be set free which is at present employed wastefully. Here, as so often is the case, co-operation and agriculture must go hand in hand.

The Commission comment on the absence of information of commercial value regarding forest products, and of the lack of commercial methods in rendering such products available to industrialists. The chief needs here are undoubtedly the development of transport facilities; the exploitation of forests on more commercial lines; and the extension of research and experimental work on such a scale and under such conditions as to render commercial action possible. Thus, whilst the publications of the Forest Department supply information of great value, not infrequently the tests and trials which have been made are either not of a nature or are not on a scale to command commercial confidence, or safe information as to quantities available within a definite area and of the rate of reproduction is not forthcoming. As examples of these are quoted the work on the antiseptic treatment of timbers, the suitability of Indian timbers for match-making, the manufacture of paper pulp from bamboos, the possibilities of wood distillation, etc., the failure to put many of the Indian timbers on the market in the form of standard scantlings. Further, certain special industries—*e.g.* the manufacture of pencils, matches, tea-boxes, three-ply wood, etc.—depend on a continuous supply of suitable timber within comparatively restricted areas, which can often only be obtained by further sylvicultural work leading to plantations. The present staff of the Forest Department, especially in the higher grades, is inadequate to undertake such work towards exploitation and commercial development, nor is there any adequate link between it and the industrialist. These defects need remedying if full advantage is to be taken of the forest resources of India, and so vital is transport that for certain areas where conditions are difficult and timber plentiful a staff of forest engineers is advocated.

Most of the useful minerals—*e.g.* coal, iron, lead, zinc, copper, manganese, mica, tungsten, chrome, bauxite, magnesite, gold, etc.—have been located, and most are being worked in India; but the location is not always commercially ideal, and in many cases further investigation is necessary to warrant commercial exploitation. The mining rules were found, on the whole, to work well, but leases were often complicated and elaborate, and there was at times a lack of elasticity in the administration of the rules, defects in part attributed to a want of an expert mining inspection staff on whose advice the Government could rely. Some witnesses referred to the need of such staff to check wasteful methods by lessees especially, as, unfortunately, private royalty owners in India do not, as a rule, watch to see that their properties are developed economically. The Commission recommend such inspection on all Government concessions. Pursuant to the policy which we shall see running through the whole of their report—viz. to bring the work of the economic departments of Government more into touch with business circles and render their labour more useful to business men—they recommend the preparation in each province of mining manuals, embodying the Government of India rules, the local rules and orders, and also notes by the Geological Department on local mineral resources.

Except in Madras, where useful practical pioneer work has been done, fisheries have, on the whole, been neglected in other sea-board provinces. There is much scope here for further practical work, but the trade everywhere needs organisation.

Thus generally, so far as the existing economic Departments of Government and the local supplies of raw material are concerned the Commission find that:—

1. The raw materials for industries exist.
2. More attention—varying, of course, with the different departments—should be paid to the commercial and industrial aspects and developments of those resources and to the presentation of information in forms convenient, useful, and satisfactory to the business community. In some cases tests may even have to be carried right through to the pioneer factory. In every case it means more men and, in most cases, some closer link between the departments and the industrial and commercial world.

Power.

Without cheap supplies of power the mere existence of raw materials is likely to be of little avail to industries, and a note of warning can almost be detected throughout the Commission's remarks on local supplies of power. The distribution of coal in India is irregular, and though the Gondwana fields supply excellent coking coal the percentage of ash is high, calorific value low, and therefore the radius of its economic use under conditions of railway

transport restricted. Recent and projected metallurgical developments — *e.g.* the steel industry—will increase the demands thereon, and the Commission strongly recommend an early expert survey on the coal position with a view to introducing economies in the methods of mining and consumption.

In regard to oil, no new fields have yet been located equal to the three main ones in Burma, which are being drained, and consequently much attention is directed to new sources of power, notably gas from wood fuel for use in internal-combustion engines of all but the smallest units, of industrial alcohol, and, above all, of water-power for hydro-electric installations. Prospecting for water-power should not be left entirely to private enterprise, but should be definitely undertaken by Government. Only Government can determine the conflicting claims which must arise—*e.g.* those which arise in displacing an agricultural community to make a reservoir, etc., or those resulting from the reservoir being in one State and the factories which use the power in another; also only Government can undertake the long-period gauging operations needed on so many Indian rivers which are liable to seasonal variations; and only Government can formulate precise rules for the grant of concessions, etc. They suggest that where power is distributed over wide areas and to many consumers the work of distribution should be undertaken by Government; but in cases where the power is used by one consumer, as in metallurgical or chemical works established by private agency, the single consumer may be granted concessions to create his own water-power. The Government of India have already appointed special officers to make a preliminary hydrographic survey. The principal criticisms against the present working of the Electricity Act were that in some provinces the rules were too rigidly enforced or sometimes wrongly interpreted, and that inspectors were unwilling to assume the responsibility of relaxing such rules even when it was obviously demanded. The Commission strongly recommend that inspectors should generally be men of higher professional qualifications, and with business and commercial experience of electric supply undertakings.

The Industrial Deficiencies of India.

It is convenient to turn from these recommendations on the materials basal to industry to the conditions of industry in India as described by the Commission. They found that there has been a greater specialisation of agricultural products by localities, a wider and more varied demand throughout the country for most kinds of articles, and a tendency of larger industries to concentrate in a few centres, leading towards congestion in the chief ports of Calcutta and Bombay.

This last has, especially in Bombay, become serious, and the tendency for industries to cluster at the chief ports is in part attributed to the operation of railway rates on goods. It is recognised that the question of railway rates is a very difficult and intricate one, intimately associated with the question of the volume of traffic offering. But whether, as a result of the competition of interests between different companies or systems, or of that between rival ports, rates on produce consigned to ports and on imported goods passing inland, are frequently low as compared with inland rates. As the policy underlying the whole of the recommendations of the Commission depends on the acceptance of the principle that "the efforts of the country in future will be directed towards bringing raw materials to the most finished state before export," the Commission lay down as a governing principle in railway rating that inland traffic should be rated as nearly as possible on an equality with traffic of the same class over similar distances to and from ports.

There must be exceptions; but they press for the acceptance, as far as possible, of this principle in the case of raw materials conveyed to, or of manufactured materials conveyed from, an Indian manufacturing centre. They say, further, that the rates on traffic to ports should be determined by a consideration of what the export traffic can stand over its whole journey to the port of foreign destination, and not from any desire to divert traffic from one Indian port to another. Such competition between ports or systems has also led in some cases to low rates on imported goods. The Commission think that such rates, except on machinery and stores for industrial use in India, might be somewhat raised. Where "scale" or "tapering" rates are charged, they hold that a consignment travelling over more than one line should be charged a single sum, based on the total distance carried. They recognise that they heard only the complaints, and whilst recommending that the principles they mention be borne in mind when rates are under consideration, they advocate no one-sided policy of administering the railways as a means of

subsidising industries irrespective of financial considerations.

Whilst avoiding discussion of many other matters of railway administration, *e.g.* routing of traffic, risk notes, etc., they are sure that commercial and industrial interests will obtain more effective representation with the Government of India on railway matters if it be possible to add a commercial member to the Railway Board, and if Departments of Industry, to which reference will be made later, are created. Without expressing any opinion on particular projects, they ask for closer attention to the improvement of water transport, especially in Bengal, Burma, and Assam. These recommendations on transport have been taken here as they affect both the possibility and the location of industries, and as, in the opinion of the Committee, railway rating and questions of transport have tended to accentuate industrial congestion in the main ports.

But to revert to the description of the industrial position as the Commission found it. They were impressed by the high financial prestige of the chief agency firms, and of the position of confidence they had gained by long years of work, marked by efficient management, cautious finance, and watchful attention to their clients' interests. On the whole, though, these firms have been inclined to develop commerce rather than industry. Until 1914, one of the bases of modern organised industry—viz. local supplies of steel—had been lacking in India. The large textile industries relied on imported plant and imported stores. The large railway system has been developed from imported material. Large and excellent local engineering shops have been established, but these are mainly assembling and repair shops, without any corresponding equipment for actual manufacture —a fact of considerable importance in the matter of training skilled workmen. In 1913–14 the imports of machinery were valued at nearly £5 million, and of galvanised iron, tin plates, steel sheets, at £13 million sterling. Generally speaking, industries based on the technical sciences have been disregarded. When attention is turned to articles, the deficiencies will seem still more surprising to one only accustomed to European conditions. India can build a small marine engine, provided certain essential parts are imported; but she has not a machine to make a nail or a screw. Practically all machine tools, steam engines, boilers, oil and gas engines, wire ropes, steel springs, textile machinery, porcelain goods, agriculturists' tools—*e.g.* spades, shovels, pickaxes—rubber goods, etc., are imported. The danger to the country of such a condition in the event of an interruption of sea communication is obvious. But within the last decade local supplies in varying degree of steel, and also in the first stage of lead, zinc, copper, have been made available, and while among the deficiencies there are several articles which could only be manufactured successfully by firms already experienced therein, and in the possession of the secrets—which firms would probably have to be given special facilities to come to India—there are other articles which, if capital, business management, knowledge, suitable facilities, information and training were forthcoming, could be established by local enterprise.

The Commission say that, except in Bombay, which has led the way in locally-managed large enterprises, Indian capital and ability has, on the whole, been used more successfully in trade, money-lending and commerce, than in local industries; and that several of the failures of small industrial ventures have been mainly due either to lack of business aptitude or commercial and industrial experience in classes which have had little opportunity of acquiring them.

Scientific Services.

The Commission thus answer the first part of their reference affirmatively. New industrial openings are offering in India. It is, however, clear from the rest of their report that if these opportunities are to be made use of locally much remains to be done. They proceed to consider in turn each of the present drawbacks, and indicate how far the Government can help towards removing them. They thereby outline a national policy of industrial improvement, covering a number of parallel lines of advance. On one line they place as essential to industrial development the maintenance of a staff of technologists and scientific experts. The absence of such technical officers to whom Government can refer for opinion, has caused, in the past, undue hesitation in the grant by Government of reasonable concessions to enterprise, whilst the almost complete absence in India of consulting experts has rendered it difficult in the past for Indian enterprise on anything but a large scale to obtain sound and disinterested advice. Moreover, it is not easy for manufacturers in India to apply directly to local conditions work done elsewhere. The mere application of such results to Indian materials and conditions not infrequently involves research work of a complex and

difficult character. At present, experts to deal with such questions have to be imported from abroad, and consequently attempts are either made to do without them, or their fees form a heavy charge on a new enterprise. The necessary research cannot, as a rule, be satisfactorily performed abroad. For it to have its full value it must be done systematically and in close touch with local conditions. The best intentions and the wisest policy of industrial encouragement will never have their full value unless preceded by systematic work on the country's natural resources. Thus the Commission unhesitatingly recommend a very substantial increase in the scientific and technical services of the different economic departments. They are also in favour of specialised institutes of research, similar to the one at Pusa, which concentrates on agriculture, and that at Dehra Dun for forest questions. These should be located, as far as possible, in centres where the particular industry flourishes, so as to be in close touch with industrialists and industrial enterprise and work. Thus Jamshedpur—the new name of the young town of Sakchi—would afford great opportunities for a research institute specialising in a wide range of metallurgical and chemical problems. The number and location of such institutes must, however, be determined by another Committee. The services of such specialised institutes should be at the disposal of industrialists as repositories of technical and industrial information and advice. Regulations should be framed to encourage *bonâ fide* applications for assistance and information. Private work for extra remuneration, which would include that of a regular consultant, should only be undertaken with permission, which should be sparingly granted. As regards the publication of results, there is generally no objection to immediate publication where it is a matter of pure science or of non-competitive development work. The Commission consider that all such research work should be looked upon as the property of Government (the data of research being the property of the applicant), who should decide regarding publication. They lay stress on the fact that at times the results should not be published broadcast, but communicated confidentially to the person interested therein, or to one who can make most use thereof.

The recruitment of such scientists is an administrative question, on which the Commission point out several difficulties which arise from independent recruiting by different Governments. Under such a system, it is difficult to offer adequate non-competing terms, and also difficult for some Governments to retain a sufficiently large staff, so that one scientist is, in fact, called upon to deal with a variety of problems. In all such work, however, quality is of the first importance. Such methods of recruitment also tend to isolate scientists from their fellow-workers in that science. They therefore recommend that all the departments of local governments should pool their different scientific needs according to sciences, and among the men employed the science and not its application would be the bond. Thus there would be an all-India chemical service, on which the Agricultural, Educational, Forest and Industrial Departments of the various local governments, etc., would draw for their requirements. The members of these services must at first be recruited from England, but as the teaching of science develops in the Indian universities, they will be mainly drawn from men trained in India. Study leave should be granted after a man has been in service three years, and is specialising on some branch.

Technical Training.

The Commission having thus outlined proposals for providing scientific consultants and research workers, pass on to the thorny question of industrial and technical education. Here they find inadequate provision for training artisans, practically none for training Indians to be supervisors and foremen, and they do not approve of the methods hitherto followed for training the higher ranks of industry. The training given in industrial schools is of little value. At their best, such schools are defective instruments of education. They are the only ones possible for helping the village craftsman, but they are altogether unsatisfactory for supplying any of the grades of labour in factories and organised industries. On the other hand, the grant of State technical scholarships to Indians to proceed abroad has generally failed to supply the higher class of labour and direction required in works. At first these scholarships seem to have been given on an assumption that any Indian student of fair intelligence and good education could assimilate information and gain industrial experience abroad in a time much shorter than is considered necessary for the young men in their country; and on return to India could apply that information and experience and shoulder the responsibility which its application involved. Regulations recently issued have remedied

much of this, but the Commission would much prefer to see all training given in India—scholarships abroad only being granted to such men as have gone through their full course in works in India, have committed themselves to an industrial life, and clearly need experience in some special branch of their industry not as yet fully developed in India. This question of training of all ranks of Indian labour affects fundamentally the prospects of India's industrial advance. The present almost complete absence of Indians as chargemen, foremen, and supervisors in works and factories is a grave weakness in works organisation, if the idea of an industrially advancing India is to be realised. At present the men in most of these grades are imported, thereby necessarily increasing the cost of production and adding to administrative difficulties. Successful supervision implies, in addition to technical skill, a knowledge of business, including the control of labour and a capacity to judge the quality and output of work. This cannot be taught at school. It can only be learnt from actual experience of works and factories, with their long hours and hard conditions. In some industries, which can be described as manipulative, such as machine making, mechanical repair work, pottery and glass making, tanning, textiles, etc., long practical experience is needed to train a competent supervisor. In this class of industry the proper place for such and for higher industrial training is in works large enough to employ a number of apprentices for whom theoretical teaching can be provided in class-rooms attached to the works; but the student is an apprentice subject to works routine and works discipline. In some cases, works are too small in India to provide for apprentices, or, as in textiles, ordinary factory work does not provide facilities for instruction. Then resort must be had to special workshops or instructional factories attached to technical schools—a costly makeshift. Where such a course is unavoidable, it must be followed by work in a commercial factory on a very low salary or as a pupil. There is another class of industry which may be described as operative or non-manipulative, in which an account of the automatic or semi-automatic character of the plant knowledge can be more quickly acquired. Such industries are oil and rice milling, the manufacture of sugar and chemicals, etc. In these the necessary higher training can best be acquired first in technological institutions, where, in addition to his particular branch some training in mechanical or electrical engineering can also be given to the student. If, however, a student is to rise in his profession further experience in works is needed.

The above distinctions are not rigid, but they form the broad lines and principles upon which higher industrial training must be sought. The Commission leave their proposals there, illustrating their principles by working out in detail a scheme for training men in engineering shops and works. These at present form India's most important need, and considerable facilities for training them in India exist.

First the Workmen.—Primary education is necessary. Training at present in many works is largely haphazard. Apprenticeship should remain as at present on a contractual basis. Every apprentice should during shop hours be given elementary technical education suited to his trade, including drawing and mensuration, so that at least he can understand a plan and work from it. In large works a special supervisor is needed to see that in each shop these apprentices are properly employed. Such supervision is still more necessary in the case of apprentices and pupils training for foremen and engineer officers. English, where there is a demand for it, should be taught as an extra, outside hours. Night schools after hours have not proved satisfactory media for the technical training of boys.

Foremen.—The present provision for training such men is hopelessly inefficient. The effect of this on industry is directly evident by the comparatively low state of efficiency of the plant in many factories which do not employ a large proportion of imported men in this grade. On the one hand, the educational attainments of the workmen are too low to fit them for such posts; on the other, the stipends and prospects offered fail to persuade the educated classes to spend a number of years as workmen, though that is the only and the essential way of acquiring that practical experience which will fit them later to hold immediate charge of specialised sections of a workshop or factory. The attempts of some technical institutions to substitute for such training instruction followed by workshop practice reverses the order in which instruction is best given, affords no familiarity with strenuous shop conditions, and is not likely to succeed. The railway shops are now receiving the sons of their staff as apprentices for training as foremen, etc., and the Commission consider that the terms offered to draw apprentices from the Indian middle classes should be

improved. Stipends in every case should be on the same scale dependent on length of time and efficiency of work. Either hostels should be provided or suitable board allowances should be given. Apprentices should start work between the ages of fifteen and eighteen, and be apprenticed for four or five years. Technical classes would be held alongside actual works practice. Government can aid by grants towards the cost of technical classes or hostels, etc.

Mechanical Engineers.—The present chief engineering colleges in India have trained capable civil engineers, but the system whereby, after taking his degree, a student goes round the various shops in works making notes and sketches, but rarely doing actual work, is worse than useless as a training in mechanical engineering. The requisite training can only be given in works, and the system adopted should be similar to that outlined for training supervisors, but more advanced, and the student should be older and better educated at starting. He should be paid wages at a workman's value, but only about one-third of his time of four or five years would be actually spent in the shops. The existing engineering colleges should be prepared to give advanced courses to students in specialised branches after they have completed the above training. Obviously the prevailing idea throughout these courses of training is close association with actual works conditions at an early stage. The present leading engineering colleges could well be developed into technological institutes, with more advanced ones as needed at suitable centres.

As the private industrial employer will be the ultimate judge of the value of all this training, the control should be with the departments of industries it is proposed to set up, rather than with that of education, except in the highest technological colleges, which will be affiliated to the universities as the engineering colleges now are.

Other Forms of Government Aid to Industries.—Cottage Industries.

State assistance to industry can usefully be given in other forms varying with the nature of the industry than by solely providing consultants and officers for research and by fostering practical industrial instruction. There are, roughly, three classes of industries — viz. cottage industries, organised industries catering for local markets, larger organised industries involving heavy capital expenditure, large-scale production, and supplying wider or even foreign markets. Cottage industries still form an important feature of Indian life, and are neither so primitive in their processes nor so decadent as is often alleged. Changes have, of course, occurred. Thus the import of brass sheets has almost extinguished the brassfounder, but has greatly extended the business of the makers of brass hollow ware. Even in hand-loom weaving the tendency is, on the whole, towards increased consumption of yarn. The chief disabilities from which these workers suffer are lack of education, indebtedness varying but sometimes extreme, and unorganised markets. For these classes of workers efficient industrial schools are useful, but in many cases better tools, better plant, and intelligent subdivision of processes are needed. The encouragement of master workmen controlling a small factory or giving out work is inviting, but for success such a leader must not only be a master in his work, but also possess commercial business aptitude. Co-operation forms the most promising remedy for indebtedness. Here is a wide field for non-official workers, but competent organisers are few, especially where the co-operative sale and purchase of goods are concerned. Little organised effort has also been made to extend the markets for Indian cottage and artistic ware, beyond sending carpets to Europe, and Madras handkerchiefs to Africa. At Madras, Cawnpore, and Bangalore, the local governments have opened useful depots for the exhibition and sale of genuine village work, but these depots have not been sufficiently aggressive in their business methods to exercise any real effect. More could be done by organised efforts in securing wider markets for such goods. There is also evidence to show that the village worker does not despise new tools when these are properly brought before him, as witness the spread of the sewing-machine and fly-shuttle. In fact, cottage industries are not dead but a living part of the Indian economic system, and *mutatis mutandis* they should benefit by study, demonstration and organised assistance, just as the agriculturists are to-day benefiting from the efforts of the provincial departments of agriculture. This is distinctly a sphere of work for the proposed provincial departments of industry.

Large Industries.

Existing large organised industries already have their own competent experts, and will rarely look to Government except for accurate economic data and for some scientific research.

The case of the inception of new undertakings of this class is, however, different, and presents scope for specialised technical and scientific assistance in the preliminary inquiries and for assistance with information regarding markets.

Small Organised Industries.

This class of industry possesses great possibilities suited to Indian enterprise, but in the past ventures have often been handicapped from the start by the purchase of unsuitable plant or by the uneconomic location of the factory. With the cheap labour of India it is not always the wisest to buy the latest thing in automatic machinery, but efficiency in the processes of conversion and extraction to avoid waste are essential. It is important to the small industrialist to be able to get disinterested advice regarding the purchase of his machinery and the location and lay-out of his contemplated factory. Similarly, after the factory is started, the owner or manager can derive much benefit from periodical inspections of his plant and advice regarding it. In the present conditions of India it is not sufficient to sell a power-plant to a man up-country and leave him with it. In Madras, where, to the great benefit of agriculture, over a thousand internal-combustion engines have been bought and are in use by agriculturists, it has been found that many gladly pay an annual fee for periodical inspection and advice by a departmental mechanical supervisor. This question of efficient maintenance is an important one to small industrial ventures in India, and could well be supplied by district supervisors.

Assistance of the kind outlined above for the three grades of industry is a legitimate form of State activity, and necessarily presupposes in the provinces a qualified expert staff and district organisation.

Further, in occasional circumstances, where private enterprise is not forthcoming, a local government would be justified in trying a pioneer factory to solve some of the initial difficulties.

Local Purchase of Government Stores.

In a separate category from the above falls the local purchase in India of Government requirements. The existing rules are in the main satisfactory, but only the Railway and Ordnance Departments possess sufficient inspecting agencies. Without such agency, and often in ignorance of the producing capabilities of other parts of India, local indenting officers not unnaturally rely mainly on the Store Department of the India Office in spite of rules. The war has shown that even many firms were in the habit of buying abroad articles which were made equally well in India. This system of easy indent on England has also given rise to an undue diversity in orders for the same class of article which, if standardised, would at times justify a local factory in installing special plant. Witnesses qualified to speak on the point were strongly of opinion that a proper organisation for local purchase of Government stores would do much to assist Indian industries. The inspecting agency which such practice would require would also form one very efficient agency for industrial intelligence in regard to which information in India is at present defective. The Commission recommend the purchase as far as practicable of all Government and railway stores in India and the creation of an organisation for their purchase and inspection. This agency would work in close co-operation with the departments of industry. Many questions arise as to how far purchase should be provincial and how far centralised, and to what extent some indents should still be referred to the India Office. To advise on these subsidiary points the appointment of a small expert committee is recommended.

Commercial and Industrial Intelligence.

The Commission consider that there is scope for much improvement in the collection and presentation of commercial and industrial information, especially as regards industrial employment and production, and the conditions of overseas trade, but to be of any use it must be up to date. Statistics and information on economic matters should be commented upon by the Department most directly charged with the development of those industrial or economic subjects. The appointment of an Indian Trade Commissioner in the City to represent Indian trade interests, stimulate Indian export trade, and assist the Imperial and Provincial Departments by answering definite inquiries, is approved. The staff of his office should, however, include at least one Indian assistant and members seconded for short periods from the Agricultural, Forest, and Geological Departments. The desirability of establishing official trade information agencies also in East Africa and Mesopotamia should be considered.

Land Acquisition and Labour.

The legal difficulties in obtaining a complete title to land in India have often embarrassed industries. General compulsory acquisition in

favour of industries is not recommended, but where the difficulty arises through a specific law preventing an agriculturist from selling to any but another agriculturist, that obstruction should be removed when the sale is for an industrial enterprise or for the housing of industrial labour. The provisions of the general Act should also be applied under safeguards for the acquisition of land for housing labour, and even within certain limitations to the acquisition of land for the industry itself when the development of such industry will be in the interests of the general public. If it be held that the present Act does not cover such cases it should be amended. Evidence shows that labour in India is content with a very low standard of living, and is much less efficient than in corresponding grades in Western countries. An increase in wages not infrequently means less work. In fact, to produce more efficient work a general rise in the standard of living and health is necessary. This connotes more education, improved housing, and general betterment, especially in housing. In the less congested centres—*e.g.* in Madras, on the outskirts of Calcutta, on some of the coalfields and at Jamshedpur, etc.—some companies have shown, and are showing the way in providing, one- or two-storied, single-roomed tenements, recreation and training, for their labour, but in the congested areas, especially in Bombay, the frequency with which labour moves from mill to mill and the readiness with which lodgers are accommodated, cause great housing difficulties. For Bombay special recommendations are made, including the removal of the railway workshops outside the city, the location of new industries only in certain localities, and a building programme within the city. Chiefly owing to the propensity of Indian labour to loiter no recommendations are made regarding factory hours, but under the wide head of "welfare" there is vast opportunity for rendering labour more efficient. This is largely work for employers and private associations. Such methods include benefit and workmen's compensation funds, co-operative stores and credit societies for workmen, sports, the care of health, care of children, etc.—in fact, all those measures which tend to create and foster a spirit of solidarity in the factory. A few enlightened employers have started, but Government can do little in this sphere by direct action.

Banking and Finance.

Evidence points to a considerable accumulation of capital in India, and to a steady increase in savings, but its availability for industry differs greatly in different parts. In the country districts finance remains, in the modern sense, unorganised. Banking facilities do not exist for, or are not understood by the agriculturists, who look with distrust on deposit accounts, and whose unbusinesslike habits are anathema to banks. There are thus still many small towns in which the transfer of money is a purely personal transaction, but which, if they were in Europe or America, would possess their branch banks. Thus clearly the finance of the country is not fully available for its own development. In the Presidency and larger towns, matters are better, and money is forthcoming to follow beaten lines of proved success or names which have won confidence. Even so, there are complaints about the rigidity of loans under the present system, and the middle class industrialist or trader finds difficulty in offering the security of approved names or of approved stocks. The wider extension of banking facilities throughout the country is necessary, though it must not be forgotten that this small industrialist, who chiefly complains, often fails totally to exhibit his financial position in a form intelligible to a banker.

In considering the class of agency best suited to provide initial and current finance for industries, the Commission are of opinion that the industrial trust or financial corporation is too directly committed to particular enterprises to be suitable. Industrial banks are more flexible, but as a wide industrial basis does not exist in India, they must combine ordinary banking with industrial activities; it is essential, however, that they have large capital and that capital—share and debenture—and long term deposits, be alone used for industrial encouragement. The capital of such a bank should be high in proportion to its total business; precautions are necessary to avoid allowing any group or industry too large a share of its funds; loans on plant, buildings and land should be carefully limited, and most of its industrial business should be in the provision of working capital; it should provide initial capital with caution, and at least, at first, should not itself float companies. Any Government financial aid to industries should ultimately be made through banks, and the Commission ask for the early appointment of an expert committee to determine what additional banking facilities are necessary for initial and current finance of industry; under what control such industrial banks should work; and what form Government assistance should take.

The development of banking facilities will take time. The Commission have been so impressed with the difficulties experienced by the middle-class Indian industrialist in obtaining finance, that they propose, as a temporary expedient, a method whereby Government may assist, ultimately turning over all the business to the banks. Where enterprises with a paid-up capital of, say, from Rs. 5,000 to 1 lakh, find such difficulties, the local industrial department, after full investigation of the case by its technical staff, and by its committee of business men, may assist them by a cash credit subject to suitable limits opened with a bank. The Government would guarantee the bank the principal, and an agreed rate of interest. The applicant would be charged a somewhat higher rate, part of which would be retained by the bank for its trouble, and part retained by the Government. This class of applicants would thus be introduced to banks, and banks—in order to retain the higher interest—would tend to take over the whole business.

For large industries direct Government financial assistance is rarely needed or advisable. It may be necessary, however, to supply an industrial deficiency in the interests of national safety. That, however, is a matter for the Imperial Government. Occasionally a new industry or process may have such an important bearing on the economic development of the country, or its extension to a new locality may benefit local consumers or producers so markedly, as to justify financial help by the local government, subject to their general powers of financial sanction. This help may be given as a guarantee of dividends, to be repaid subsequently from profits. Such form of help is suited when the dividend paying stage is likely to be long deferred. Or it may be made by loan, in cases in which the assets are of a particularly liquid nature; or by agreements to purchase output for a limited time. The last can be given freely, when the industry is a new one to India, but only with great caution otherwise, and provided always, of course, that Government need the articles. The strictest preliminary inquiries must necessarily be made, and there must be Government audit and inspection. Occasionally it may be advisable for Government to nominate a director. Where such aid is given to a company, the company should be a rupee company, and the Government should have some say in the allotment of shares, to induce the Indian public to take an interest in industries. The above proposals are not rigid, but give the general principles, as well as the general possibilities and limitations of financial assistance.

Departments of Industries.

Such is the diagnosis of the position, and such are the recommendations made by the Commission to deal with it. It is clear that they forecast great changes of method.

1. On the part of the State, a much more intimate association with commercial and industrial development, a smoothing away of some of the administrative annoyances in the working of certain Acts, the more complete collection of information, and its presentation in forms more useful commercially, a marked increase in the amount of Government stores purchased locally, the provision of facilities for research, advice and education, the fostering of cottage and small industries by demonstration, advice, organisation, and occasionally with finance, and aid to large ones where necessary in national interests.

2. On the part of the people a willingness to submit to the hard practical work of the factory, a readiness to understand and ameliorate the conditions of labour, and the adoption in many cases of more businesslike methods.

The co-operation and sustained effort of both sections are needed to achieve the far-reaching aims of the Commission. It only remains to outline the machinery which they consider Government will require to discharge the functions allotted to it. Most of the work, especially that connected with the smaller industries, would be done in the provinces, but both Provincial and Imperial Departments of Industries would be needed. Owing to the close inter-relation of industries and agriculture, both these departments should in the Provinces, but not in the Imperial Government, be under the same Member of Council. The Provincial Director of Industries should be an executive officer solely responsible to Government, and be a Secretary to Government to ensure direct access, but he should be assisted in his work by a Board which should be consulted on the budget, the expenditure of funds, the appointment and promotion of the superior staff. The Board should number not less than six and not more than twelve, and consist mainly of non-officials, representing merchant, manufacturing and financial interests, nominated either by Government or partly by public bodies. For special purposes it should have power to co-opt members. The heads of these provincial departments should ultimately be drawn from the

Imperial Industrial Service, but must possess the business sense, and be capable of business organisation. At first they will have to be drawn from official or commercial circles. The special experts and scientists under this Board would be drawn from the Imperial Scientific Services described above, but in addition a staff of mechanical engineers and local officers will be needed to help the smaller and cottage industries. Industrial education, the local administration of the Factories, Electricity, and Mining Acts would rest with the Director.

Above the provincial organisation an Imperial one is necessary to safeguard and foster the larger industrial undertakings, *e.g.* the smelting of metals, the manufacture of chemicals, of rubber goods, of electrical machinery, the better utilisation of forest wealth for drugs, oils, etc., to control the general trend of industrial policy, the general administration of the various industrial Acts, etc., the purchase and supply of stores, the direction of the technical and scientific services, etc., and the dissemination of commercial and industrial education. These duties should be in the hands of a new Member of the Viceroy's Council assisted by a Board of three of which the Member would be chairman, without any direct executive charge. One member of the Board, who should have had both scientific training and practical experience, would have executive charge of matters dealing with geology and minerals, salt, explosives and petroleum, the chemical services and chemical research, Government factories for research and demonstration; the second, for whom business qualifications are of first importance, would deal with stationery and printing, commercial and industrial intelligence, stores, the Factories Act, the general encouragement of industries, technical and industrial education; the third, for whom business experience, but more especially engineering knowledge is essential, would deal with inventions and designs, Steam Boilers Act, electricity, ordnance factories and inspection of ordnance factories. Attached to the Board will be a Financial Adviser. The subordinates of the Board will practically all require technical and, usually, engineering knowledge, and should utlimately be recruited as far as possible in India.

The rough estimate of cost, based on prewar rates, is placed by the Commission at Rs. 124 lakhs recurring, being an annual increase of Rs. 86 lakhs above present charges and in capital expenditure at Rs. 150 lakhs, with a possible additional Rs. 66 lakhs later—roughly one million sterling on capital account and over half a million increase in recurring charges.

DISCUSSION.

THE CHAIRMAN (Sir Charles C. McLeod), in opening the discussion, said the report, being of a non-political character and uncontroversial, and with a strong constructive policy, was a very welcome document. People were very apt to forget that India was not only a country but a vast continent, with an area as big as Europe, minus Russia; a population as big as that of Europe, minus Russia; and a trade approaching £300,000,000. If the agricultural development of India was continued on a freer and more scientific scale, those figures would very quickly be doubled or trebled. There was in the report a great responsibility put upon the shoulders of Government, and he trusted that Government would be able to accept that responsibility, thereby greatly benefiting India. He thought the crux of the whole of the Industrial Commission's report lay in a sentence in the first part of the paper, namely: "If India is to advance economically, it is necessary that the basis of employment of her people be widened, her economic efforts better balanced, and her ability to meet her most urgent needs in years of stress increased." There was one point, the author mentioned, in regard to the teaching of trade to young Indians that he considered of the very first importance. There seemed to be a great disinclination amongst the manufacturers of this country to take Indian students into their factories. Why that was so he did not know, but it was very unfortunate, as the Indian students were forced to seek such training in countries like America and Japan. He held the opinion that the good of India in the future would be very much enhanced if more Indian students came to this country and learnt healthy trades instead of studying for the Bar. Another point he would like to lay stress upon was that the first call on the raw materials of India should undoubtedly be for her own industries; but in many cases there would be a considerable surplus for export, which should, as far as possible, be utilised in this country before any portion went to foreign countries. In that connection he thought the work of the Imperial Institute was of the utmost importance, as it had assisted India to develop her resources in India itself, and had also been the means of introducing Indian materials to manufacturers in that country in a way which could not, at all events at present, have been done by any local institutions because they had not had the necessary experience. The reference in the report to the work of the Imperial Institute was, in his opinion, wholly inadequate. In the last two years the Indian Trade Inquiry, which had been

conducted at the request of the Secretary of State for India by the Institute, with reference to the utilisation of Indian surplus raw materials in this country, had led to most important results.

SIR CHARLES H. ARMSTRONG (Chairman, Great Indian Peninsula Railway Company) said the report was an admirable one in every way. It explained the deficiencies of the past, and it put forward many useful recommendations for the development of Indian trade in the future. The great point was that action should be promptly taken, and although no doubt the matter was having the consideration of the Government of India and the Secretary of State, a resolution on the subject might help matters forward. He had, therefore, much pleasure in moving: "That this meeting of the Indian Section of the Royal Society of Arts, after discussing the proposals made in the report of the Indian Industrial Commission, requests the Council of the Society to convey to the Secretary of State for India, and to the Government of India, its opinion of the desirability of prompt action and the necessity of appointing a special officer with adequate staff to give early effect to such recommendations of the Commission as are approved by the Government of India." In the paper the author had referred to the vital necessity of the development of agriculture in India, and in that he (the speaker) entirely agreed. Agriculture would always be the backbone of Indian prosperity. He was inclined to think—he might be wrong—that money put into the development of Indian agriculture would in the long run give a better return than a good deal of the money which might be put into industrial enterprises during the next twenty years. He was, however, entirely in sympathy with the idea of industrial development, and he hoped that great progress would be made within the next few years in that direction. As India developed in wealth, from whatever cause, there would be—there must be—an increasing demand from this country for manufactured articles of various kinds, and therefore he felt confident that nobody need fear that industrial development in India would interfere with industrial expansion in this country. The author had stated that there had been a tendency to concentrate the larger industries at the ports, and that the reason was in great part attributable to more favourable railway rates. He (the speaker) doubted whether that was the correct reason. The question of railway rates was, as the Commission admitted, a very difficult one, but it stood to reason, he thought, that traffic to and from a large port could be handled on more favourable conditions than traffic between intermediate stations or to and from outlying districts. The recommendation which the Commission made was that traffic of that character should be equally rated whether it was being brought to the ports or whether it was being carried from one inland town to another. He felt sure that that recommendation would be sympathetically considered by the Boards of the Indian railways. He agreed, however, with the concluding remark of the paragraph, that when rates were under consideration there should be no one-sided policy of administering the railways as a means of subsidising industries irrespective of financial considerations. He thought that that was a very wise conclusion. With regard to the recommendation that the railway workshops should be taken away from Bombay and be located up country, he quite agreed that it would be a good thing both for the railways and for Bombay. The staffs would be housed under very much better conditions up country, and there would be room for that expansion which would become necessary in the future; but a move of that kind was very expensive, and it was very difficult in these days to get a sufficient amount of money for a change or development of that character. In his Budget speech Sir James Meston had stated that, including revenue expenditure, £24,000,000 would be spent during the next financial year on the Indian railways, and he seemed to think that that was a very large sum, but when it was borne in mind that the cost of materials had increased from 100 to 150 per cent., 24 millions of money to-day was not really worth more than 10 or 12 millions in the days before the war, and 10 or 12 millions was considered to be the normal requirement of the Indian railways in those days. Reference was made in the paper to the almost complete absence of Indians as charge men, foremen, and supervisors in works and factories, and some very excellent recommendations were made in that connection. He thought himself that the real reason was that Indians of that class were not sufficiently educated and had not had sufficient training for those posts. The railways had no objection whatever to employing Indians if they were educated and trained. He heartily agreed with the recommendations that had been made. It stood to reason that the railways must welcome labour of that character, because it would always be very much cheaper than imported labour. It seemed to him that at the present time what India needed mostly was a very large accession of capital. She also needed brains and initiative. She possessed all three to a moderate extent, but she would have to draw upon England for many years to come, and the policy of the present day should be to encourage the development of India by English firms and Indians working together. At present the work of the English people in India was being belittled. It was a great pity that that should be so. The English in India had done a splendid work in

developing industries. He had never, in Bombay, found any jealousy by Indians of English capital or English enterprise. He could only hope that in the great game of politics the true interests of India would not be overlooked.

MR. ROBERT MILLER (Chairman, Bengal-Nagpur Railway Company) said that the report issued by Sir Thomas Holland's Commission was of the greatest interest. It covered too wide a field to permit of more than a brief comment, but he was sure it would be studied here and in India by everyone interested in industry and commerce. It would be useful if this report could be given circulation beyond the circle of the Society. It was in Birmingham, Sheffield, Manchester, and the North where knowledge of India and its resources as a competitor as well as a customer was most needed. There was scarcely a paragraph in the report which was not suggestive. It was well indexed and easily read. One of the healthiest features, or the most significant, was the indication of an intention on the part of the Government to adopt, and not merely talk about, a more liberal policy than hitherto towards what was called private enterprise—that was, the enterprise of business people as distinguished from enterprise by the Government itself. The old tradition—not yet dead—had been that private enterprise was merely a paraphrase for robbing the Government. There was, however, one point to which he would refer as a blemish in the report. The field of industry could not be enlarged, or its cultivation developed, without facilities of transportation, and the report, except in Chapter XIX., made scarcely an allusion to the fundamental fact. Chapter XIX. mentioned in a superficial way a technical subject of a most complicated character. The fixation of rates which the report spoke of was a department of the science of transportation, and required experience to solve its countless problems. The allusion it made to the rates subject suggested that it was intended as a red herring to distract attention from the real motive, which would seem to be to build a wall of protection round India, and to foster the growth of internal industry without reference to the equal necessity for the growth of commerce. The rest of the world was as necessary for India as India was for the rest of the world. Except for Chapter XIX. not a word was said for roads, rivers, or railways, and without them neither industry nor commerce could grow.

SIR J. D. REES, K.C.I.E., M.V.O., M.P., said that a most important consideration hung upon the paper read by Mr. Chadwick. In England labour was threatening great strikes. Little did labour understand that many of our industries were dependent upon India, that it was the greatest market we had, and that it was a market which had unlimited powers of absorption at cheap rates; but it touched bottom directly those rates were raised. As soon as there were great strikes here and coal went up in price, and production was stopped from Lancashire or elsewhere, so soon would Japan come in, and away would go our trade. It was of the utmost importance that knowledge of Indian trade should be spread abroad among the English electorate. He and many others had felt anxious lest, in the new reforms which must come, everything was not carefully designed to secure that all-important supremacy for the Government of India and the Parliament of England in the future government of India. That he believed to have been done, but there was a fear that not sufficient representation was given to the immense interests of British capital. For his part he would never support any proposals unless he thought that that was to be granted.

SIR RALPH ASHTON agreed as to the extraordinary value of the report. He thought it was a report which had been turned out by workmen for workmen, and there was evidence of real work all the way through it. But in India it always seemed to him that there was a tendency to build the upper storey before the foundation, and though the report went to fundamental things, it yet suffered from that taint in many respects. Therefore, he should have very much hesitation in accepting the resolution, which appealed to Government. He had no faith in Government-forced industry. There was plenty of sound wisdom among the people of India if they could get at it, but as a rule it was not the wise whose voice was heard. Dealing with the question of coal, when he first went out to India the output was about 1,000,000 tons a year. At the present time the output was 17,500,000 tons. In 1913 he had made a calculation that in 1932 there would be needed 40,000,000 tons of coal, in order to keep up with industrial development. The other day he had been interested to read a paper published by the Society, in which the writer calculated that, in 1930, 36,000,000 tons would be needed. That meant that, in the course of about thirteen years, the output of coal had to be increased by 23,000,000 tons, over 1,500,000 tons a year. There was, therefore, a tremendous scope for enterprise in that direction.

SIR HAROLD A. STUART, K.C.S.I., K.C.V.O., said he would only refer to two points in connection with the report. One was with regard to cottage industries. He had always felt that it was very doubtful whether we were conferring an altogether unmixed benefit upon India by introducing into that country the industrial system of the West. When he went into an industrial town in this country, and saw the long lines of unlovely streets and squalid surroundings in which our industrial workers

lived, he always thought that it would be much better if, in India, cottage industries were encouraged rather than factory industries, and he was very glad to see that the report laid emphasis on the fact that the cottage industries were by no means in a decadent condition in India. He knew it was a very difficult problem to keep cottage industries alive in competition with factory industries, but he was inclined to think that something might be done by developing the very great hydro-electric power which was to be found in India, and perhaps in giving every weaver a little electric power with which to drive his loom, or the metal worker with which to drive his lathe. He agreed with what Mr. Robert Miller had said about the importance of communications. Mr. Miller had pointed out how very important it was to all industries in India that the roads, railways, and canals should be developed, and he (the speaker) thought Mr. Miller should also have added the ports; but he had not indicated in any way how the money was to be obtained. He had been reminded, as Mr. Miller was speaking, of a remark which had shocked the rather narrow-minded financial pundits of Simla, made by Sir Edward Law when he was Finance Minister. Sir Edward had said he believed it would be for the benefit of India if all the Government-owned railways could be transferred back to private ownership. He (the speaker) felt sure that, reflecting upon the miserable rate of development of railway communications, many people would be inclined to think there was much to be said for that view. The Government of India had always been handicapped by what he called their narrow views on finance. It was the finance of an accountant and not a national finance. They never got beyond the bounds of 3 per cent. or 3½ per cent., and the result was that they could not raise nearly enough money to provide the amount required for the development of that great country.

The resolution was then put and carried.

Mr. T. J. Bennett, C.I.E., M.P., in proposing a vote of thanks to the author for the great service he had done the Society by laying before it the substance of the Commission's report, said it was to be hoped that the Government of India would take the report in hand at once, and take action upon it as soon as it possibly could, because there was a great advantage in having what might be called a healthy variety in the subjects which were inviting public interest and public discussion. There would be some very big Indian matters laid before the people of India, and before the people of this country before long. It was just as well that for the time being the whole of the interest of the people, whether in India or in England, should not be concentrated upon one particular class of subject, and he hoped that public opinion would seriously apply itself to the great and important report of the Commission.

Sir Abbas Ali Baig, K.C.I.E., C.S.I., LL.D., in seconding the resolution, said the report of the Industrial Commission would inaugurate a new era in the economic history of India, and the change of policy which foreshadowed an active participation of Government in industrial activities would be most welcome to those who visualised the India of the future—the near future it was to be hoped—as a strong and self-reliant unit of the British Commonwealth of Nations. The general tone of the speeches showed that the angle of vision in regard to industrial questions, especially in regard to the notion about the conflict of Indian economic interests and British commercial and industrial interests, had changed. That angle of vision, he was sure, would continue to be changed in the future, if it had not changed already; but he noticed, from the references made to agricultural matters, that there might yet be some adherence to the policy of the East India Company, which wished to limit the industrial destiny of India to the production of raw materials. If there were any who held those views at the present time, he would only refer them to the agricultural and economic history of Bengal, by way of reinforcing one of the arguments of the Chairman. One hundred and fifty years ago Bengal was a howling wilderness, marshy and insalubrious, where people were exiled by way of punishment. Bengal to-day, industrially, was a very advanced province, comparatively speaking. What was the position to-day, as far as the British manufacturer was concerned? Did Madras, a large province, put more money into his pocket than Bengal? That was a question which the British manufacturer and industrialist should deliberate upon. Then some apprehension had been expressed in the remarks of speakers, and even in the paper itself, that agricultural development might suffer. Imagine a country like India: did anyone believe that agricultural development in India was ever going to be stopped, whatever its industrial position might be? Supposing for the moment that the same proportion of the population of India took to manufacturing industries, was not the world large enough to absorb those manufactures from India? He did not remember the present statistics, but a few years ago there were only about 800,000 operators in the power-driven factories of India. Supposing there were a million or two millions or more to-day; what was it—what fraction of the population was that number? Could a number equal to the normal increase of population, which was about fifteen millions, be diverted annually to non-agricultural pursuits? So that that fear need not be entertained. On the

contrary, agricultural activities must continue to develop with the increase of population, especially as the principal industries of India—cotton and jute—were based upon agriculture. The industrial problem in India was a more vital one than the political problem, which had attracted so much attention, and no nobler task could devolve on British genius and Indian patriotism than to make all those problems, industrial, political, educational and so on, into a convergent force for elevating India to that position of economic strength and self-dependence to which the country was entitled.

The resolution was then put and carried.

Mr. Chadwick, in reply, said no thanks were due to him; he was merely trying to be the mouthpiece of the Commission's report. He knew, as a fact, that India was very anxious to hear the opinions of this country. India was confident that she was going ahead industrially, and she meant to go ahead industrially, and she wanted to carry the goodwill of this country with her in her efforts. He was quite certain, from what had been said that afternoon, and what had appeared in the papers, that she was assured of that goodwill. She was not going ahead in the way of competition, but she was going ahead in the way of widening the basis of employment for her peoples, for a more varied and more intense use of her own natural resources, and of the abilities and funds and capital of her own peoples and of those who had gone there and made that country their home.

Mr. Cecil J. Longcroft (Messrs. David Sassoon & Co., Ltd.) writes:—The bigness of India is illustrated by the two recent reports which have been placed before the peoples of Great Britain and India. Both reports are voluminous, and we are indebted to Mr. Chadwick for the clear summary he has given of that of the Industrial Commission. His office is one of the results of this report, and that part of the commercial community interested in India appreciates the manner in which he discharges his manifold duties. Merchants and others have availed themselves of the expert knowledge he possesses. The two lines of development, agricultural and industrial, are not always divergent, but are in some cases parallel. Raw material is the basis of industry. The important point is to develop the trade in a manner consonant with the genius and needs of her people. Too much stress upon agriculture might involve loss of industrial opportunities of which quick advantage would be taken by a neighbouring trade rival; and, again, to neglect agriculture in the hope of bringing India into industrial alignment with the Western world would be to take great risks. India, by her climatical conditions and the consequent characteristics of her peoples, would seem to incline more towards agricultural development. Famine is the "skeleton in the cupboard." Complete dependence upon agriculture involves difficulties and dangers. A sound principle of selection must be found. Probably some of the suggestions in the report will need further consideration. To attempt to carry out all suggested developments at one time, or even in quick succession, would be to court discouragement. On the other hand, there may be a danger of pigeon-holing the report, which must be guarded against. To begin with, one or two well-thought-out schemes provide the best hope of progress. India has had its full share of commercial vicissitudes. Indigo fell before the synthetic product, and opium has recently met a violent death. She has still a virtual monopoly of certain products, but experience teaches that monopolies are short-lived in days of scientific research, and the discovery of new areas within which cultivation of transplanted trees, shrubs, etc., may be successful. Rubber may be instanced. The report says that "raw materials are not generally deficient," but, while this is true, their wide distribution with only inadequate transport makes development more difficult. India's natural resources have clearly not been fully developed. Waste is the enemy of economic progress. Valuable products are to-day wasted, or only partially where they should be vigorously cultivated. This would appear to be true in connection with certain tanning materials. One of the conclusions of the report is that commerce rather than industry has engaged the attention of the agency firms. The uncertainty of exchange has played some part in determining the policy of such firms. The long "lock-up" of capital is not always attractive. The report is valuable, and, it may be hoped, will be followed by action in which experience and experiment shall be wisely combined.

Mr. Ed. C. de Segundo, A.M.Inst.C.E., M.I.M.E., writes endorsing Mr. Miller's suggestion that the paper read by Mr. Chadwick should be circulated in the great industrial and manufacturing centres throughout Great Britain. Mr. de Segundo continues:—In Article 90 of the report it is stated that "a large proportion of the crop of oil seeds, valued at about 36 crores of rupees, is exported in normal years and the remainder consumed locally." It is not quite clear, however, whether the valuation of 36 crores refers to the total crop of oil seeds or to the proportion which is exported. It is also not clear whether cotton-seed is included in this valuation. Presumably not, because the average area on which oil-seeds are grown is stated to be about 15,000,000 acres, whereas we know that the area under cotton alone is anything

from 22,000,000 to 27,000,000 acres. Further on it is stated that "probably any excess of oil over 5 per cent. in the cake used for cattle food is wasted." In this connection the results of experiments carried out some years ago under the direction of the Norfolk Chamber of Commerce are of interest. Sixty sheep were divided into two lots of thirty each and fed for sixteen weeks on the same ration, consisting of linseed cake, clover hay, chaff, and swedes. The only difference was that the linseed cake fed to one lot contained 6 per cent. to 7 per cent. of oil, while that given to the other lot had 15 per cent. to 16 per cent. of oil. The average gain in weight per head during the sixteen weeks was 33·5 lb. and 38·3 lb. respectively. The difference in favour of high percentage oil cake was therefore roughly $\frac{5}{33\cdot 5}$, or nearly 15 per cent., but the proportion of quantity of oil in the high percentage to the low percentage cake was $\frac{16\cdot 5}{6\cdot 5}$, or nearly 254 per cent. This indicates clearly that the result of feeding the high percentage oil cake was in no way proportional to the extra oil fed to the sheep, and, so far as my knowledge goes, I think the committee would have been justified in stating categorically that oil exceeding 5 per cent. on the weight of the oil-cake fed to cattle is wasted in the sense that it is not efficiently utilised, and could be turned to much better account if sold as oil. In a bulletin recently published at Washington by the United States Department of Commerce, it is stated that the annual loss suffered by India, owing to the absence of a scientific cotton-seed crushing industry, is 31·5 crores of rupees. Taking the average cotton-seed crop at even 2,000,000 tons, this figure presupposes a value of something over 150 rupees, or £10 per ton of seed, and the valuation is, therefore, presumably based upon present-day prices for, and values of, the cotton-seed and its products, which, however, cannot be expected to maintain their present level in the future. I recently had occasion to go carefully into the average annual value of the Indian cotton-seed crop, and on the assumption that 1,500,000 tons were potentially available for crushing, my figures showed that on the basis of pre-war trading conditions, prices and values, the gross value of this quantity of Indian cotton seed, if milled according to up-to-date methods and under skilled superintendence, should be about 20 crores. The establishment and development in India of the oil-seed crushing industry, on modern scientific lines, is probably beyond the power of private enterprise, for many reasons with which those intimately acquainted with the habits and customs of the inhabitants of India will readily appreciate; but it is otherwise when the practically unlimited resources, intellectual as well as financial, of the Government are brought into play, and, in view of the fact that the world is short of hard oils and fats, and as there would appear to be no likelihood of the world's demands being even satisfied for some years to come, it would surely be the part of wisdom for the Government promptly to accept and act upon the recommendations of the Commission in regard to the development in India of this hitherto sadly neglected source of revenue. Of course, the degree to which the Indian oil-seed crop may be turned to account is intimately bound up, not only with the fiscal policy that may be adopted for India, but also with that of the countries in which India would naturally seek a market for the surplus products of the milling of her cotton seed. There is, however, one point in connection with the export of oil seeds from India which must not be overlooked. We all know that, speaking generally, the material prosperity of a country is a function of the relation of its exports to its imports. At first sight it would appear sound policy to encourage the export of oil seeds from India. This is, however, by no means necessarily true. Let us assume, merely for purposes of argument, that the average protein content of the oil seeds exported is 25 per cent. It has been found that the mysterious substance called protein contains about 16 per cent. of nitrogen. Thus, if 1,000,000 tons of oil seeds were exported from India, it would involve taking 40,000 tons of nitrogen out of the soil of India. A certain amount of fixation of nitrogen from the atmosphere is always going on by means of bacteria and minute organisms, by the agency of which the nitrogen of the atmosphere is converted into protein substances in the plant. I am not aware of any exact experiments indicating the relation of the quantity of nitrogen thus obtained by the plant from the atmosphere to that obtained from the soil, but the proportion obtained from the atmosphere cannot be very large, and the farmer must look for the return to the soil of the nitrogen exported in the oil seeds, to ammonium sulphate or nitrates, or some other form of fertiliser. Clearly then, the real revenue derived from the export of oil seeds is the price received *less* the price that has to be paid for the quantity of ammonium sulphate, or whatever it may be, necessary to give back to the soil the nitrogen carried away in the oil seeds exported. We are thus again brought face to face with a question of fiscal policy. I have only just indicated one or two important points connected with this question of the utilisation of oil seeds; but space will not permit of my developing my argument further. For the same reason, I must refrain from dealing with what appear to me to be points of fundamental importance in connection with the proposals made by the Commission for the advancement of technical education in India. If I might venture upon a suggestion to

the Council of the Royal Society of Arts, it would take the form of a recommendation that Mr. Chadwick's able summary of the report should be discussed, point by point, at a meeting, or if need be, a series of meetings, thus affording an opportunity for examination into the vital issues arising out of the unquestionable fact that, as Mr. Chadwick says in his paper, "if India is to advance economically, it is necessary that the basis of employment of her people be widened, her economic efforts better balanced, and her ability to meet her most urgent needs in years of stress, increased."

OBITUARY.

Sir William Crookes, O.M., F.R.S.—The Society has lost one of its most distinguished Fellows by the death of Sir William Crookes, which took place at his residence in London on the 4th inst.

William Crookes was born in London in 1832, and educated at the Royal College of Chemistry in Hanover Square, then under the direction of A. W. Hofmann, to whom he became assistant. On leaving the college he held appointments first at the Radcliffe Observatory at Oxford, and then at Chester Training College; but about 1855 he returned to London, which continued to be his home for the rest of his life. His first scientific publication appeared in 1851; it dealt with the selenocyanides, and was the starting-point of the investigations by which he made his name as a chemist. In 1861 he announced the existence of a new element, thallium, a sample of which he showed at the great Exhibition of 1862.

It is scarcely necessary to recall in these columns Sir William Crookes's brilliant work on "radiant matter" and other purely scientific problems, as it has already been ably summarised elsewhere, particularly in the *Times* of the 5th inst., but it may be worth while to mention his services in connection with the early days of electric lighting. His researches into the means of producing high vacua made the modern electric lamp a commercial possibility. His own house in Kensington Park Gardens was the first to be lighted with electricity, and the original lamps used there he made himself.

Sir William Crookes, who was knighted in 1897, received many scientific honours both in his own country and abroad. The Royal Society, of which he was elected a Fellow in 1863, awarded him three of its medals—a Royal Medal in 1875, the Davy Medal in 1888, and the Copley Medal in 1904; appointed him to deliver the Bakerian Lecture on three occasions; and finally chose him as president. The French Academy of Sciences gave him in 1880 a gold medal and an extraordinary prize of 3,000 francs in recognition of his work on radiant matter and molecular physics, and in the following year he was chosen to serve as a juror at the Paris International Electrical Exhibition. He received the Order of Merit in 1910. At different times he acted as President of the British Association, the Chemical Society, and the Institution of Electrical Engineers, and for some years, from 1900, he was secretary of the Royal Institution. Besides publishing a large number of scientific papers, he wrote, or edited, English translations of many books on pure and applied chemistry, such as a "Practical Treatise on Metallurgy" (1869); "Select Methods in Chemical Analysis" (1871), which has gone through several editions; "The Manufacture of Beetroot Sugar in England" (1870); "Handbook of Dyeing and Calico Printing" (1874); "Dyeing and Tissue Printing" (1882); "Wagner's Chemical Technology," and others. He became editor of the *Quarterly Journal of Science* in 1864, and in 1859 he founded the *Chemical News*, which he owned and edited until his death.

Sir William Crookes's name first appeared in the *Journal* as long ago as 1854, when an article by him and John Spiller, "On a Method of Preserving the Sensitiveness of Collodion Plates for a Considerable Time," was reprinted from the *Philosophical Magazine*. His lecture on the discovery of thallium, delivered at the Royal Institution, was printed in the *Journal* of May 22nd, 1863. In 1874 "Some Suggestions on the Question of River Pollution" were published by him there, and in the following year he took part in a conference held by the Society on the Health and Sewage of Towns. In 1885 he was awarded the Society's Fothergill Prize "for his improvements in apparatus for the production of high vacua, and for his invention of the radiometer," and in 1900 the Albert Medal "for his extensive and laborious researches in chemistry and physics, researches which have in many instances developed into practical applications of the arts and manufactures." In 1885 he was elected a life member of the Society, and he served on the Council as a Vice-President from 1905 to 1909.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 14...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Dr. H. E. Armstrong, "Problems of Food and their connection with our Economic Policy." (Lecture III.)
Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. O. Braham, "Demonstration of the Carbon Process."
Geographical Society, Kensington-gore, W., 5 p.m. Dr. J. Ball and Mr. H. K. Shaw, "The Astrolabe à Prisme."

Tuesday, April 15...Petroleum Technologists, Institution of, at the Royal Society of Arts, John-street, Adelphi, W.C., 5.30 p.m. Sir Frederick W. Black, "Some War Problems of Petroleum Supply."
Photographic Society, 35, Russell-square, W.C., 7 p.m. Paper by Mr. F. F. Renwick.
Colonial Institute, Central Hall, Westminster, S.W., 4 p.m. Professor P. Carmody, "Agriculture in the Tropics for Ex-Soldiers."
Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Dr. A. L. Bowley, "The Measurement of Changes in the Cost of Living."

Wednesday, April 16...Aeronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Dr. F. C. Lea, "Aluminium Alloys for Aeroplane Engines."
Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Mr. A. A. Barnes, "Rainfall in England: the true Long-average as deduced from Symmetry." 2. Mr. C. E. P. Brooks, "The Secular Variation of Rainfall."

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—April 11, 1919.

No. 3465. APRIL 18, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,465. VOL. LXVII.

FRIDAY, APRIL 18, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

CANTOR LECTURE.

On Monday afternoon, April 14th, PROFESSOR HENRY E. ARMSTRONG, F.R.S., delivered the third and final lecture of his course on "Problems of Food and their Connection with our Economic Policy."

On the motion of the Chairman, DR. M. O. FORSTER, F.R.S., seconded by DR. J. A. VOELCKER, a vote of thanks was accorded to Professor Armstrong for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 19th, 1919; the Right Hon. LORD MOULTON, G.B.E., K.C.B., F.R.S., in the chair.

The paper read was—

DISTRIBUTION OF HEAT, LIGHT, AND MOTIVE POWER BY GAS AND ELECTRICITY.

By SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

Our industrial civilisation of to-day is founded upon the use of the coal deposits of these islands; when our coal is exhausted then our type of civilisation must change. England may then become the garden of the world, so longed for by Ruskin and our artists, but it can no longer be its workshop. If our great overseas dominions increase their population, as hoped for by Professor Seely, it may be that the United Kingdom will remain the intellectual and strategic centre of a still great British Empire, but it is certain that it will no longer support its present population approaching forty-six millions. The industrial revolution began for us about the middle of the eighteenth century, at a time when our population was ten and a half millions; by 1801 we had increased to fifteen and a half millions; and 1914 saw us with forty-six millions. In that year the population of our own race in the British Empire outside of these islands was about sixteen millions. Our total British population for the United Kingdom and overseas was sixty millions. Our industrial era is, therefore, nearly 170 years in existence—a short period of our history. How long can it last?

At our present rate of consumption and export, about 250,000,000 tons per annum, our British coal supply will be exhausted in five hundred years, but the rate of mining is increasing, and if this continues without change, our coal will end in less than two hundred years. In that time it is possible that Canada may increase to fifty millions and draw the necessary coal from its own mines and those of the United States of America, while the other overseas dominions may carry another fifty millions of white people among them. Then the United Kingdom might return to its population of 1830, about twenty millions, leading a largely self-supporting agricultural life, utilising all its water resources for the motive power required for railway transport and such industries as remained. Science, literature, and art might still flourish, but the conditions of life would be more difficult and necessitate a greatly reduced population.

The recurrence of an agricultural phase in our history would be attended with much suffering, and we naturally desire to avoid this fundamental change as long as possible.

Consequently the problem of coal conservation possesses an importance far greater than that of mere technical interest; it concerns our whole population in a vital manner, and

it forms a most appropriate subject for the consideration of men so widely separate as the Prime Minister and Mr. Smillie.

It is a matter of vital importance to conserve all our sources of heat and mechanical energy, but in considering how to do it many difficulties arise. The first thing to bear in mind is the impossibility of the creation either of matter or energy by any action of man or machine. No progress in science can create energy. Some writers in the press appear to think otherwise. Discussing a lecture on the fuel and motive power supplies of the world, a newspaper article states :—

"Surely Dr. Clerk, or anyone else, cannot imagine that coal will serve any useful purpose 2,000 years hence, at the present rate of scientific progress."

The notion that energy can be created in some unknown way is still held by members of the public, and the word "electricity" at once brings up the idea of some mysterious process by which this is accomplished.

Science has disclosed many strange and hitherto unknown facts, but in the midst of rapid advance, two fundamentals form the basis of all scientific reasoning; the indestructibility of matter together with its uncreateability, and the indestructibility and uncreateability of energy.

We are all agreed, then, as to the vital importance of the coal and energy conservation problem. For more than one hundred years engineers have devoted much study and experiment to it. The results are seen in the development of heat engines of different kinds, steam and internal combustion, in the development of the dynamo, and the study of the laws of electrical generation and distribution, and in the rise of the gas industry, and with it the invention of the internal combustion engine, the Bunsen burner, the incandescent mantle, together with the study of the chemistry of coal tar and the formation of many chemical products used in the preparation of fertilisers, ammonia products, dyes from nitro benzol, toluol, and other bodies for producing high explosives.

The gas industry found its origin in the inventive power of Murdock, the colleague of James Watt, in Birmingham, and that of Lebon, in France, in the beginning of the nineteenth century, and the imagination and daring of Winsor led to its introduction for use in London by the Chartered Company in 1812.

Lord Moulton, in a most valuable presidential address delivered last year, tells us that "Within twenty years of this first attempt, some 200 public gas companies existed in the kingdom, and by the middle of the century all urban populations must have been supplied with gas."

In the year 1912 there existed 826 authorised gas undertakings, of which 520 were companies and 306 local authorities, and about another 800 non-statutory undertakings, mostly supplying villages and rural areas.

A capital of some £170,000,000 is now invested in gas works and the industries engaged in the manufacture of gas plant and gas consuming appliances.

The utility of the gas service is undoubted in peace; but Lord Moulton, speaking as President of the Institution of Gas Engineers, on June 4th, 1918, tells us something of the functions of the industry in war. He said :—

"No one has had such a unique opportunity of witnessing the response of the industry to new and exceptional demands made upon it by reason of the war. Your industry—typically peaceful in character and aims—has furnished material for purely war purposes, without which it would have been impossible to maintain the fight. I have thus learnt, as well the flexibility and resourcefulness of the industry, as the importance to the nation that all its varied capacities should have free scope. Not only have the benzol, toluol, and ammonia produced by it furnished the materials for our high explosives, but in the direction of other needs of very different nature, it has given promise of similar usefulness. I have thus been brought to reflect on its capacities of service to the public in war as well as in peace; and as I am here, not as one who has himself done anything to advance the industry, but as one who has had occasion to judge and to testify to its capabilities and its successes, I think that I can best utilise this occasion by giving you the fruit of these reflections."

The gas industry of the United Kingdom carbonises about 20,000,000 tons of coal per annum, of an average estimated calorific value of 13,000 British thermal units per lb.

The process is economical, as the average thermal efficiency of carbonisation is approximately 71 per cent.; that is, after the completion of the process, the three main products produced — coal gas, coke, and tar—are capable of evolving, on complete combustion, 71 per cent. of the original total heat of the coal. Of this, 25 per cent. is obtainable from coal gas, and 46 per cent from the coke and tar. If we consider the whole of the heat used in the process, amounting

to 29 per cent., to be debited against the principal product, coal gas, then, to obtain 25 heat units in the form of gas, it is necessary to use a total of $25 + 29 = 54$ heat units of the original coal. That is, the thermal efficiency of the gas making process is $\frac{25}{54} = \cdot 46$, or 46 per cent.

Gas, like electricity, is ultimately used to produce heat, light, and motive power, and both services must be compared as to capacity and efficiency for supplying the three wants of the consumer, and the accurate evaluation of each depends on a full knowledge of the relative division as to heat, light, and power of both systems. This is not accurately known, either for gas or electricity, and accordingly it is better and simpler to compare the capacities and efficiencies of each separately.

The capacity for generating heat will first be considered.

From the figures just given, if the whole of the gas produced be completely burned, the heat evolved will be equal to that which could have been produced by the combustion of 25 per cent. of the original coal, amounting to 5,000,000 tons; but the efficiency of production of gas is 46 per cent., so that $\frac{5}{\cdot 46} = 10\cdot 86$ million tons of coal are used in the process, say, 10·9 millions, leaving still a heat equivalent in the remaining coke and tar of 9·1 million tons of the original coal.

The electrical industry of to-day originated in Faraday's great discovery made in 1831, and its rise to its present position of importance depended on the work of many inventors and investigators; but I have given an account of its progress already in this room,* so that I need not deal with it now.

The electrical generating stations of the country, which are supplied by coal, according to Mr. D. Wilson, the technical adviser to the Coal Controller, in the year ending March 31st, 1918, generated 4,674,000,000 of electrical units on a coal consumption of 3·47 lb. of coal per unit, the calorific value of the coal being 11,600 B.Th.U. per lb., the thermal efficiency of generation being 8·5 per cent., and the total consumption of coal in the year 7·3 million tons. This coal is of lower thermal value than gas coal, in the proportion of 11·6 to 13; correcting for this, $7\cdot 3 \times \frac{11\cdot 6}{13} = 6\cdot 5$. Had the coal been of the same heat value as gas coal, the quantity consumed in a year by electricity would have been 6·5 million tons. The amount of heat which could be generated by the electric current actually produced is 8·5 per cent. of the total heat of the coal, and $6\cdot 5 \times 0\cdot 085 = 0\cdot 55$, shows that this heat could have been obtained by the combustion of 0·55 million tons of coal at 13,000 B.Th.U. per lb.

* Trueman Wood Lecture, *Journal*, December 7th, 1917.

Comparing first the present capacity for heat production of the two industries as now existing, the gas industry has $\frac{5\cdot 0}{\cdot 55}$ = nine times the capacity of the electric industry. To supply the same amount of heat as the gas industry, the electricity generating undertakings of the country would require to consume $6\cdot 5 \times 9 = 58\cdot 5$ million tons of coal of the same calorific power as that used by gas. Gas only requires the consumption of 10·9 million tons, so that it is $\frac{58\cdot 5}{10\cdot 9} = 5\cdot 36$ times as efficient.

The thermal efficiency for the generation of heat quantity by gas is over five times that of electricity.

Taking the efficiency of transmission of gas and electricity as approximately 90 per cent., the heat capable of generation by the consumer remains at the same proportion.

So far, the discussion deals only with the relative quantities of heat energy which can be supplied to the consumer by the two systems. When the consumer receives his gas, he produces heat by its combustion, and the efficiency of use varies with the nature and relative perfection of the apparatus employed for heating rooms, for heating and boiling water, for cooking ovens, and other apparatus in domestic use, or for metal melting furnaces or welding, or metal heating and tempering as used in factories. If the efficiencies of the electric apparatus required to produce heat in home and factory were the same as those of gas, then the thermal efficiency ratio would remain constant. This, however, is not the case. Thermal efficiencies of use vary considerably. An examination has been made of the efficiencies of gas fires as contrasted with electric radiators or heaters for rooms, for water heating, cooking oven, and metal melting.

In heating rooms by gas, to apply 27 heat units to the raising of the room temperature by radiation and convection, requires the use of 100 heat units at the gasworks, while in heating by electricity, for 7·6 heat units so applied, 100 heat units are used at the electricity generating station.

Heating and boiling of water by gas, applying 22·5 heat units to the work, requires the use of 100 at the gasworks, while electricity only applies 3·8 heat units to this work for 100 at the station.

For cooking by oven, gas applying 3·4 heat units uses 100 units at the gasworks; but electricity only utilises 1·5 heat units for 100 used at the station.

For metal melting, utilising 14·4 heat units gas requires 100 at the gasworks, and electricity utilises 4·1 heat units for 100 at the generating station.

In all these cases a much greater heat quantity must be used at the electricity generating station than at the gasworks, to apply the same quantity of heat required for domestic and manufacturing purposes, varying from two and a quarter to six times. In a general heat supply by both systems, the average value will depend on the proportion of the different types of use included in each system. With the proportions estimated as existing in the gas heating services of the country, the probable value of the ratio of thermal efficiencies from user apparatus to gas works, or electricity generating station, is about four; that is, electric heat supply, if substituted for gas heat supply, would necessitate the consumption of four times the fuel or thermal value. In this case, instead of consuming 10·9 million tons of coal annually, if the whole gas or current be converted into heat, 43·6 million tons would be required.

From this it is obvious that, in so far as electricity is substituted for the ordinary operations of heating by gas, coal consumption would be very seriously increased.

The case is different, however, when light is produced by the two systems; here, also, the efficiency of the apparatus of light production varies considerably; but to compare the best known of both, it is desirable to consider first the inverted incandescent mantle at ordinary gas pressure, and the so-called one-watt electric lamp. The inverted incandescent lamp requires the use of 47 B.Th.U. at the gasworks for each candle-power hour obtained by the consumer. The one-watt electric lamp requires the use at the generating station of 54 B.Th.U.; the half-watt lamp only requires 31 B.Th.U.

Accordingly, if all the lamps used electrically were of the former type, electricity would require a greater heat consumption than gas; but if all were of the latter type then electricity would be more economical than gas.

Again, all the incandescent burners used are not of the inverted type; a considerable proportion consists of the upright type, which is less efficient, requiring 82 B.Th.U. per candle hour. If we assume the gas-lighting system to consist of equal numbers of vertical and inverted burners, then 64 B.Th.U. would be required per candle hour. High-pressure incandescent burners reduce the heat consumption to 23 B.Th.U. per candle hour, and flame arcs in electric lighting come even below that economical figure, using only 13 B.Th.U.

From these figures it is evident that the competition between gas and electricity in lighting is very keen, and conditions other than heat economy will determine as to the system to be applied.

Statistics as to the number of lamps and the nature of the various types in use in both systems are much required, in order to determine the most economical combination from the thermal point of view.

The motive power position is much less complicated.

At about 75 per cent. of full load a gas engine of the ordinary type will deliver to the consumer as actual or brake horse-power 11 per cent. of the heat used at the gas works to produce the necessary gas for distribution to the consumer, while an electric motor will deliver, also as brake horse-power, only 6·8 per cent. of the heat used at the electricity generating station. The efficiency of the gas power production and distribution is thus over 1·6 times that of the electricity system.

The results which have been given refer to the estimated average performances of the whole of the gasworks and electricity generating undertakings of the country as in operation at present; but, as would be expected, there is some variation in the values given by the different gasworks and central stations.

The average thermal efficiency of carbonisation has been arrived at by the examination of a year's working of large gas undertakings such as the Gas Light and Coke Co., the South Metropolitan Co., and other London and provincial companies.

The efficiency values for the generation of electricity have been taken from the statements of Mr. David Wilson, the technical adviser to the Coal Controller.

Both systems show that in individual cases much higher efficiencies are at present obtained than the average figures.

Professor J. W. Cobb, C.B.E., B.Sc., gives the

following values as obtained by tests made at a single gasworks:—

THERMAL EFFICIENCY OF CARBONISING GAS COAL IN HORIZONTAL RETORTS.

Gas produced	23·5
Coke sold	52·6
Tar produced	6·6
	82·7
Heat used and lost in manufacture	17·3
	100·0

The late Mr. J. G. Newbigging has made long-continued trials of continuous vertical reports with the following results:—

THERMAL EFFICIENCY OF CARBONISING GAS COAL IN CONTINUOUS VERTICAL RETORTS.

Gas produced	23·6
Coke sold	53·5
Tar produced	5·1
	82·2
Heat used and lost in manufacture	17·8
	100·0

In these two cases the thermal efficiencies of carbonisation are respectively 82·7 and 82·2 per cent. instead of the average 71 per cent. The two efficiencies of production are, therefore, 57·6 and 57·0 per cent., on the assumption that the whole heat loss of the process is debited against the principal product, coal gas.

If all the gasworks of the country operated at the same as the two examples, then the thermal efficiency of production would be 57 per cent. instead of 46 per cent.

As $\frac{57}{46} = 1 \cdot 238$, the thermal efficiency would be raised by 24 per cent.

Mr. David Wilson, in discussing the thermal efficiency of the generation of electricity throughout the country, stated that there are altogether 421 steam-driven central stations producing in one year 4,674 millions of Board of Trade electrical units on a consumption of 3·47 lb. of coal per unit at the thermal efficiency of 8·5 per cent.

Of these 421 stations, 381 produce a total of 2,399 millions electrical units on 4·32 lb. of coal per unit at an efficiency of 6·8 per cent. The remaining forty stations produce 2,277 million electrical units on 2·57 lb. of coal per unit at a thermal efficiency of 11·5 per cent. Of these forty stations one produces over 40 million units on a consumption of 2·32 lb. of coal per unit at a thermal efficiency of 13·05 per cent.

If all the electricity generating stations of the country could be raised to the efficiency of the best single station, then the thermal efficiency of generation would be 13 per cent. instead of 8·5 per cent. As $\frac{13}{8 \cdot 5} = 1 \cdot 53$, the thermal efficiency would be raised by 53 per cent.

The power of heat generation per lb. of coal used at the gasworks or electricity generating station on the average is $\frac{\text{gas}}{\text{electricity}} = \frac{5 \cdot 36}{1}$, so that allowing for the highest existing efficiency of both, it becomes $5 \cdot 36 \times \frac{1 \cdot 24}{1 \cdot 53} = 4 \cdot 34$.

At their present best results electricity is still inferior to gas in power of producing heat in the ratio of 1 to 4·34.

Taking the value 4 as calculated for the average result of the country, including the consideration of the relative efficiencies of apparatus in use for gas and electricity, the ratio now becomes $4 \times \frac{1 \cdot 24}{1 \cdot 53} = 3 \cdot 24$. Assuming the same heat-using apparatus to be in operation with current supplied with the thermal efficiency of the best station and gas supplied also equal to the best example, gas will deliver to the consumer 3·24 times the heat obtained by electricity for a station or gasworks consumption of, say, 1 lb. of coal in each.

In the production of light the case of electricity is now improved relatively; the one-watt lamp requires the use of 35 B.Th.U. at the generating station; while the half-watt lamp only uses 20·3 heat units per candle hour. The inverted incandescent burner now uses 38 B.Th.U. per candle hour, so that illumination by one-watt lamp and inverted incandescent burner would consume practically equal amounts of heat for equal light. If, however, the whole illumination of the electrical system could be accomplished by half-watt lamps, then electricity would have a considerable advantage over gas; it would only require per candle power, $\frac{20 \cdot 3}{38} = 0 \cdot 534$ of the heat units used by gas.

This assumes that gas lighting is wholly accomplished by inverted incandescent burners and electric lighting by half-watt lamps.

But high-pressure incandescent gas-burners produce light on a consumption of 19 B.Th.U. per candle hour, and if they could be adapted to the smaller power lights used for interior illumination, gas would again show a thermal efficiency equal to electricity.

Flame arc electric lamps give the still lower consumption of 9 B.Th.U. per candle hour, so

that if they could be utilised for smaller lights, they, too, would reduce further the heat consumption of the country for producing light.

With regard to motive power, under what may be termed the best gasworks and electricity generating conditions the gas engine gives a return of 13·6 per cent. brake horse-power for 100 heat units used at the gasworks, while electricity returns 10·4 per cent.

In motive power gas has still a distinct thermal advantage over electrically transmitted power.

From these facts it follows that the real competition between gas and electricity from the point of view of coal conservation arises in the field of illumination, and not in that of heating or motive power.

Some eminent electricians think differently; for example, Mr. Ferranti stated, in his presidential address to the Institution of Electrical Engineers in 1910:—

"It appears that with a problem such as we are discussing it is fundamental that the energy in the coal should be converted at as few centres as possible into a form in which it is most generally applicable to all purposes without exception, and in which it is most easily applied to all our wants, and is, at the same time, in a form in which it is most difficult to waste or use improperly.

"We are therefore, forced to the conclusion that the only complete and final solution of the question is to be obtained by the conversion of the whole of the coal which we use for heat and power into electricity, and the recovery of its by-products at a comparatively small number of great electricity producing stations. All our wants in the way of light, power, heat and chemical action would then be met by a supply of electricity distributed all over the country."

Later in the address Mr. Ferranti states:— "After very careful thought on the subject I have come to the conclusion that, in order to supply electricity for all purposes, it would be necessary, amongst other things, to have a conversion efficiency of not less than 25 per cent."

This opinion of Mr. Ferranti's in 1910 forms the basis of the super-station proposals of which we now hear so much in the reports of official committees in press and in Parliament.

The general sense of the articles written by supporters tends to the belief that by the substitution of electricity for gas great coal-saving would be made throughout the country. From the foregoing discussion it is evident that so far as concerns heat and motive power a great fuel loss would be incurred by this substitution, and it is only in the case of lighting that electricity competes substantially with gas.

The engineers of the gas industry fully recognise the important position now filled by the distribution of electricity from central stations, and they wish to co-operate with electrical engineers in producing the necessary electrical supplies in the manner best calculated to conserve the vital coal resources of the country. They desire to point out, however, that gas and electricity are both required for the purposes of our civilisation, and that for progress in both industries it is necessary that they should develop in friendly rivalry, each performing the task for which each system is specially suited.

It is necessary, however, as a preliminary that the electrical engineers should recognise the limitations of electricity distribution and use, as well as its undoubted superiority for some special purposes.

Mr. Ferranti's claim to superiority over gas in coal economy—that is, the conservation of our coal supplies—is not, as will be seen, justified by facts.

The report of the Coal Conservation Committee recommends the erection of a small number of great central electricity generating stations, sixteen is the number suggested, in units of about 50,000 kilowatts, and the distribution of current throughout the country for use in producing heat, light, and motive power. A higher thermal efficiency is promised for these great stations than is obtained by the best station in operation at present. The coal consumption suggested is 1 lb. per electrical horse-power hour—that is, 1·34 lb. per electrical unit. Good coal would be required for this, so 13,000 B.Th.U. per lb. is taken, and at that value the thermal efficiency of electrical generation would be 19·6 per cent. The best station of to-day gives 13 per cent., so that the proposed super-station would give $\frac{19 \cdot 6}{13} = 1 \cdot 5$ times its efficiency.

The average of the electricity generating stations of to-day is 8·5 per cent. thermal efficiency of generation, so that the proposed efficiency of the great super-stations will be $\frac{19 \cdot 6}{8 \cdot 5} = 2 \cdot 3$ times the average value.

But great improvements are also proceeding in the gas industry whereby the thermal efficiency of gas production will be greatly increased

and a larger proportion of the heat value of the coal transferred to the gasholder.

The main efforts of the gas industry have been devoted during the past century to increase the yield of illuminating gas per ton of coal carbonised and to the improvement of the percentage efficiency of gas, coke, and by-products production. So long as high intrinsic illuminating power was imperative, development proceeded along the line of increased economy of fuel in carbonising by the use of the regenerator and other contrivances. This led to improvement in the efficiency of gas production, but the volatile contents of the coal dealt with imposed a limit on the yield per ton of what is called straight coal gas—that is, coal gas produced by distillation only—and accordingly a limit was attained when about 25 per cent. of the original heat of combustion of the coal appeared in the station gas-holders as inflammable and illuminating gas. Thus 75 per cent. of that heat remained to be accounted for by the heat value of the coke made, the tar and oil separated, and the heat required for the process of carbonisation and other secondary processes, such as steam, raising for pumping, driving exhausters, and all the other mechanism of the modern gas-works.

Obviously greater financial economy would follow if a larger percentage of the total heat of coal could be delivered in the form of gas to the station holders. As all the volatile matter of the coal had been driven off in the retorts, it became necessary to convert the carbon itself into inflammable gas; hence arose water gas and carburetted water gas processes, now so largely used to supplement the distillation process. These operations depend on the endothermic chemical reaction of incandescent carbon and steam. When steam is passed through incandescent coke at a temperature of about 800° C. and above, some heat is absorbed and the reaction is broadly—

$$C + OH_2 = CO + H_2.$$

When the temperature falls to 600° C and lower the reaction becomes—

$$C + 2OH_2 = CO + 2H_2.$$

Both reactions absorb some heat, the first somewhat more than the second, and both result in the development of nearly equal heating value from the gas produced by a given weight of carbon. In the first case, however, the whole (theoretical) product is combustible, consisting as it does of 50 per cent. CO and 50 per cent. H by volume. In the second case, the composition is $33\frac{1}{3}$ per cent. of CO_2 and $66\frac{2}{3}$ per cent. of H. In the first case the carbon and water reaction produce relatively two volumes, and in the second case three volumes are produced, but one volume consists of uninflammable gas carbon dioxide.

In the year 1913 the carburetted water gas produced by the metropolitan suburban and provincial gas undertakings dealt with in "Field's Analysis," amounted to 15,172 million cubic feet, and the oil used to 37·3 million gallons.

Many water-gas processes have been tried, beginning in 1824, when Ibbotson increased the volume of gas by injecting steam into the red-hot coke remaining in the retort after carbonisation; but the basis of the modern carburetted water-gas systems did not appear until the time of Lowe and Tessie du Motay in America. This process, however, acted by producing weak inflammable gas mixed with nitrogen in the blowing up, preliminarily to passing steam through incandescent coke. The Dellwik process improved on this by burning the carbon to carbonic acid in the heating stage, and so reducing the consumption of carbon required to raise the remainder to incandescence. By this process, 66 per cent. of the heat of the coke consumed is obtained as combustible gas delivered into the gas-holder. A later water-gas plant improves upon Dellwik, by the use of double incandescing coke chambers, and burning such CO as is produced in blowing up in an effective system of regenerators. This apparatus raises the gas-producing efficiency from 66 per cent. to 76 per cent. Water gas without oil enrichment is known as blue-water gas, and its calorific value is about 300 B.Th.U. per cubic foot. If one volume of "straight" coal gas at 600 B.Th.U. per cubic foot be mixed with two volumes of blue-water gas, then the heat content of the gas-holder per ton of coal carbonised is doubled. That is, it now contains $25 \times 2 = 50$ per cent. of the original heat of the coal producing it. The best efficiency of coal carbonisation by horizontal or vertical retort is, as has been shown, about 80 per cent., so that one-half of the heat value of the gas stored has 57 per cent. of the heat of the coal consumed. and the other half has 76 per cent. of that of the coke used to produce it The combined efficiency of the mixed gas made separately and mixed after production is thus 66 per cent.

If, however, the distillation and water-gas processes be combined, so that the waste heat of the water-gas production be applied either externally or internally to perform the work of

carbonisation, then the gas-producing efficiency of the whole process will be considerably raised from 66 per cent. to 75 per cent. by external heating, and probably 80 per cent. by internal. So at this stage it is desirable to combine the distillation and the water-gas reaction within the same apparatus, and the continuous vertical retort system lends itself readily to a convenient and highly efficient design on the principle of heating up by burning a small quantity of carbon to CO_2, and then passing steam superheated by regenerator for the water-gas reaction and for distillation. The water gas produced would then pass through the distilling coal from the lower to the upper part of the retort, and supply the heat necessary for distillation, carrying away with it the coal gas as it was generated to the gas mains.

The excess heat of the blowing up process would maintain the external temperature of the retorts, and be further utilised by regenerator. Then the air for blowing, and steam for decomposing, would both be heated regeneratively.

By this combined process, 75 per cent. to 80 per cent. would be readily obtained as the efficiency of gas production. The efforts of the gas industry are thus at present directed to the application of internal heating to all gas-making processes. Its members are encouraged in this work by the success of the engineers of the internal-combustion engine industry, in the application of this principle to the evolution of the dilute fuel gas known as "producer gas." Many thousands of such gas producers supply power gas for gas engines at a thermal efficiency of from 80 per cent. to 85 per cent. Such efficiencies can also be obtained in coal-gas distillation and carbon-gasifying processes by the special adaptation of internal heating. The separate manufacture and mixing of the two gases would thus give a gas-producing efficiency of 66 per cent., while that of the combined internal heating system would be at least 75 per cent. If half the original heat of the coal be produced as gas at 75 per cent. efficiency, then the coal used for gas-making is 67 per cent. of the total coal carbonised, leaving 33 per cent. remaining for coke and tar, which would then contain 33 per cent. of the original heat of the coal.

With an efficiency of gas production of 75 per cent., and that of distribution as 93 per cent., the combined efficiency would thus be slightly under 70 per cent. The efficiency of power production by gas engine would then be $\cdot 25 \times \cdot 70 = 0 \cdot 175$, that is, 17·5 per cent., and the value for light and heat would improve in the proportion of 45 per cent. to 70 per cent. That is, 70 per cent. of the heat of gas production would be available to the consumer for heat production, and low-pressure inverted incandescent gas lighting would require a coal consumption at the gasworks of 30·2 B.Th.U. per candle-power hour instead of 47 B.Th.U. of existing usual practice.

Comparing now the results aimed at in the future by the projected electricity super-stations, and the perfected systems of coal gas generation, it appears that in the generation of heat gas will produce 75 per cent. out of 100 heat units used in the works to produce the gas, and the great electricity station will generate electrically 19·6 per cent. of the heat consumed in the generating station. From the heat generating point of view, gas is superior to electricity in the proportion of $\frac{75}{19 \cdot 6} = 3 \cdot 8$ to 1. For lighting the low-pressure inverted incandescent burner would use at the gasworks 30·2 B.Th.U. per candle hour at the consumer, while the one-watt lamp would now use 23·4 B.Th.U. at the station per candle hour at the consumer.

Electric lighting would thus be thermally the more economical. As to motive power, the use of 100 heat units at the gasworks would deliver 17·5 per cent. as brake horse-power to the consumer.

For the electrical generation of power, the efficiency of distribution, including station use of current, may be taken as 90 per cent., and the dynamo efficiency at three-quarter load may also be taken at the same value. The brake horse-power supplied to the consumer would thus be $19 \cdot 6 \times 0 \cdot 9 \times 0 \cdot 9 = 15 \cdot 9$.

The thermal efficiency would be 15·9 per cent., against 17·5 per cent. obtained by gas.

In the future, therefore, the only field in which electricity shows any possible thermal gain is in lighting. But even here the past record of gas invention shows that great developments are still probable.

Great advances were made in the economical use of gas for lighting by the introduction of the incandescent gas-mantle in 1895; before that time three candle-power per cubic foot consumed per hour was considered a good result, but now the inverted incandescent mantle at low pressure gives 25 candle-power per cubic foot per hour, and high-pressure lamps give from 40 to 60 candle-power per cubic foot hour. Since 1895, the light obtained from a cubic foot of gas has been increased eight-fold at low pressure and twenty-fold at high pressure.

At first the gas was but little used for heating and cooking; now it is used in enormous quantities for low-temperature work, such as heating and cooking alike in all classes of homes, in factories, business premises, hotels and public institutions, and for high-temperature work, such as gas fires and metal melting, annealing, brazing, forging, hardening, tempering, welding, and almost all other industrial processes requiring heat.

Gas is now in enormous and increasing use for light, heat, and motive power.

Ninety per cent. of all the towns gas sold is used for illumination and fuel purposes, and 10 per cent. for motive power by gas engines.

No official census of the gas industry has been taken yet, but an examination of reports from many gas companies shows the following division of heat, light and power throughout the United Kingdom to be very probable:—

PROBABLE DIVISION OF COAL GAS CONSUMED IN THE UNITED KINGDOM.

Heat	55 per cent.
Light	35 „
Motive power	10 „
	100

Using the ratios already discussed, this enables an estimate to be made as to the thermal economic effect of substituting for the present general heat, light and power service by gas, an electrical system distributing the three items in the same proportion, considering first substitution of electricity at the present average of generating efficiency of 8·5 per cent. to compare with the present average gas results both as distributed to the consumer. For this electricity would require, at the station, four times the heat consumption of gas.

Assuming the use of equal numbers of inverted incandescent and vertical lamps for gas lighting at 64 B.Th.U. per candle hour, and one-watt lamp electric lighting at 54 B.Th.U. per candle hour, electricity would require $\frac{54}{64} = 0 \cdot 84$ of the heat used by gas, and motive power $\frac{\text{gas}}{\text{electricity}}$ $= \frac{11}{6 \cdot 8} = 1 \cdot 6$.

Electricity requires to use for unit power 1·6 times the heat of gas. The heat used by electricity for the system becomes:—

Heat	55 × 4	=220
Light	35 × 0·48	= 29·4
Motive power	10 × 1·6	= 16·0
	100	265·4

In this case the substitution of electricity for gas in a general service would increase the heat consumption at the central station as compared with the gasworks, from 100 heat units by gas to 265 heat units by electricity. If a comparison be made of the probable future of both systems, in heat generation the gas is still 3·8 times that of electricity for equal station and gasworks heat consumption. Allowing the same efficiency of use as first calculated, that is $\frac{4}{5 \cdot 36} = 0 \cdot 746$, we get $3 \cdot 8 \times 0 \cdot 746 = 2 \cdot 8$. Even assuming no relative improvement in the efficiency of gas-heating appliances electricity requires 2·8 times the heat of gas. For gas lighting in the future it may be assumed that the inverted incandescent burner will become universal and the one-watt lamp practically so also.

The heat consumption is then $\frac{23 \cdot 4}{30 \cdot 2} = 0 \cdot 77$ of that of gas.

For motive power, gas is the more economical in the proportion of $\frac{17 \cdot 5}{15 \cdot 9} = 1 \cdot 1$.

The heat used by electricity for the systems becomes—

Heat	55 × 2·8	= 154
Light	35 × 0·77	= 26·9
Motive power	10 × 1·1	= 11·0
	100	191·9

In this case the substitution of electricity for gas, in a general service, would increase the heat consumption from 100 heat units by gas to 192 heat units by electricity.

It thus appears that even assuming the success of the super-electric stations to be fully realised, yet a gas service is, from the coal conservation point, nearly twice as economical. That is, it requires half the coal consumption.

So far, then, as concerns the gas industry of the United Kingdom, the new proposed super-stations would not save fuel but waste it. There is no case for electricity for the production and distribution of heat energy; there is a case in strong competition with gas for illumination, and as against the average reciprocating steam engine of the country the advent of the steam turbine of high efficiency shows a distinct advantage.

The statement made, however, in the Report of the Committee on Coal Conservation, that 80 million tons of coal are at present consumed annually for producing motive power by steam and gas, is not supported by convincing data; the estimate, too, of an average consumption of 5 lb. of coal per brake horse-power appears to be doubtful, in view of the known efficiencies of

modern steam engines of the reciprocating type. A careful census of motive power and fuel consumption in all its uses is urgently wanted in this country, and gas engineers note with pleasure the partial census of the Coal Controller's Department, and the general interest of Parliament and the Prime Minister in our urgent fuel problems. They welcome the work of the Department of Scientific and Industrial Research in establishing the Fuel Research Board, under the directorship of Sir George Beilby, and they also regard with interest the work of the Board of Trade Committee on the Water Power Resources of the United Kingdom. For the welfare of the country, it is necessary that all sources of motive power should be fully investigated and all available power utilised.

It is quite evident from the valuable paper recently read to this Society by Mr. Newlands, that Scotland alone has sufficient water-power to generate at least 2,500 million electrical units per annum. This would add over 50 per cent. to the present steam-driven electricity supply of the country without requiring the consumption of any additional coal.

The gas engine continues to increase in power and numbers. According to the Census of Production of 1907 internal-combustion engines using gas and oil in various forms amounted to 680,177 h.p. This power is much greater now in 1919; it cannot be less than 1,500,000 h.p., judging from the number of engines built and sold since 1907.

The thermal efficiency of the internal-combustion engine is much higher than that of the most economical steam turbines. The largest and best of existing steam turbines give a brake thermal efficiency of about 18·5 per cent. referred to the coal consumption in the boiler furnace, and the gas engine using producer gas made from coke or anthracite will give 28 per cent., allowing for the efficiency of the gas producer which is high—from 80 to 85 per cent.

These engines use towns coal gas with a brake efficiency of 30 per cent. of the heat of combustion of the gas, and they also use blast furnace gas, coke oven gas, and inflammable gas produced from waste wood, chips, and peat. These engines are most important factors in securing fuel economy, and they should be allowed freedom to develop in competition with steam engines of all types as heretofore.

It would be a most serious matter for the country if the development of these engines were hampered in any way.

Gas engineers fully realise the existence of a vast field for the generation of light and power by electricity. Electricity supplies energy for power in a convenient form for the operation of electric railways, tramways, small and medium power motors in factories of various kinds. It is also necessary for many electro-chemical processes for very high temperature metal welding and for all electrolytic processes. Its field is very wide, but its use as the one source of heat, light, and power by legislation would be fatal to the prosperity of the country and would largely increase the fuel consumption, already high.

Gas engineers agree with some of the conclusions of the Coal Conservation Report. It is obviously desirable that all coal used for combustion should first be carbonised in order to obtain tar, ammonia, benzol, and other useful products. This, however, must be done in such manner as to render the gas produced available for distribution to the public. The worst use to which the gas could be put is to burn it in the furnace of a steam boiler as proposed by the electricians. The only practicable method is to carbonise all coal at gasworks, and legislate to prevent the direct burning of coal, either for domestic or manufacturing purposes. Steam-boiler furnaces would then be adapted to consume the coke produced in gas-making, and an ample supply of cheap fuel would be available for the use of electrical generation and all other purposes.

The domestic fires of the country now consume about 36 million tons of coal annually; this quantity, together with the 20 millions carbonised at gasworks, gives a total of 56 million tons for the production of gas, coke, tar, and other valuable products. The coke produced from this large quantity of coal is amply sufficient, together with the poorer available coal unsuitable for carbonisation, to produce the desired increase in the generation of electricity and the heat needed for the household. At the same time great quantities of good gas would be available at the lowest possible cost for 10,000 heat units. Wherever the conditions permit, as in municipalities owning both gas and electricity undertakings, the gas and electricity generation should be combined in one works, so that all heat waste could be very greatly reduced by the combination of gas-making and steam-raising as one unit. Great heat economies can also be obtained in this manner.

Apart from economies in generation and distribution, there is still a large margin for

improvement in the construction and design of gas-consuming appliances for the production of heat, light, and motive power, so considerable that it is certain that even better thermal results will be practicable in the early future.

The intensity of effort in the production of new devices will be greatest in the field of illumination, both with gas and electrical devices. Even in gas engine efficiencies great improvements are probable: the movement as to larger gas engine units is proceeding, although at a somewhat slower rate than other gas improvements.

The extension of the industrial stage of our civilisation can only be made possible by the co-operation of the Government of the country with the gas, steam, electric, and hydraulic engineers, in order to ensure the full utilisation of all our sources of heat, light, and motive power for the good of the community, even at the cost of some legislative interference with the immediate profits of some industries.

Great sources of energy on which we depend for our very existence should be conserved with the greatest care.

In conclusion, I would repeat what I have already said in London* on October 29th, 1915:—

"Altogether the engineers of the future have before them vitally important and interesting problems, and on the success of their work depends the future of our country—whether we can support, five hundred years hence, an industrial population of fifty millions, or an agricultural one of about twenty millions. Of our immediate future I have no fear. We shall assuredly uphold our liberty and independence, notwithstanding all the warlike efforts of the Germanic powers; but our distant future undoubtedly depends more on the efforts of engineers than on the labours of war or politics."

We have already upheld our position against the Germanic powers. It is to be hoped that we shall be equally successful in conquering the powers of nature.

DISCUSSION.

THE CHAIRMAN (Lord Moulton) said everyone had been much interested and impressed by the admirable paper. In all great questions of the kind one thing had to be remembered, that when dealing with science and industry adjectival descriptions were of no use—one had to get down to figures. One had laughed for the last forty years at the solemn tone in which the word "electricity" was pronounced by those who knew nothing about it, and at the newspapers writing about ships being driven by electricity, as if electricity could be generated in any other way than other forms of power had to be generated. Of late there had been a great outburst of that kind of thing—how the country was waking up to a sense of its powers, and how the blunders of old times would be swept away, and how an almost unlimited capacity was to be obtained by the marvellous agency of electricity. All that kind of talk was of no use. Those who had studied the subject knew perfectly well that electricity was one form of energy and heat another form, and that it was possible with the greatest nicety to calculate the cost of producing and the advantage of using one or the other for any particular purpose. In the paper the author, who was cognisant of the whole question of the application of heat to industry, had taken actual figures to test the soundness of all the political arguments that had been heard as to the importance of burning coal in great super-power centres and distributing it in the form of electricity throughout the Kingdom; and in examining the matter he had pointed out that so far from the universal use of electricity leading to economy it would lead to great waste of coal. It was known perfectly well that in a lump of coal of a certain weight there was an amount of energy capable of being developed by the coal being burnt, and that energy could be calculated to a nicety. But it was latent there, and the question was how the population could best use the power for human ends. The two main things clearly were heating and lighting. To change the form of the energy in the lump of coal, big sacrifices had to be made. If converted into motive power in the shape of electricity the coal had to be burned under a boiler to make steam, which turned dynamos and produced electricity. As the author had pointed out, when coal was burned under a boiler and the energy so developed measured, it shrank down to a very small fraction of the energy in the coal, so that in generating electricity from coal something over 80 per cent. was lost, and that was the price that had to be paid for turning the energy in the coal into electricity. Four-fifths of the energy was sacrificed in changing it into something which could be distributed. The other way was to roast the coal and turn a large portion of the combustible matter into gas. What remained was partly coke and partly tar, but considering the gas alone, it was obtained in a form in which it could be sent to the house, and for that the price paid—in making the gas, in loss, waste and that sort of thing—was nothing like so big as the price which had to be paid in burning the coal under a boiler. Something like 45 per cent. of heat was obtained in the gas distributed, instead of 19 per cent. in the case of electricity. On the basis of merely comparing the distribution of heat, electricity would not be in it. Statistics had been given pointing out clearly the amount of good that gas did in the household. In connection with heating, gas was readily burnt in any position that might be chosen, and in any quantity chosen. It was much better than coal, because the combustion could be started or stopped in a moment,

* Third Thomas Hawksley Lecture, Institute of Mechanical Engineers, October 29th, 1915.

and therefore it had a very great adaptability to household needs, and energy sent round in the shape of gas was therefore very useful. Electricity could be turned into heat, but it was felt to be a very great waste to burn coal under a boiler, and lose four-fifths straight away, for the purpose of turning the rest back into heat, and one was not surprised to find that the amount of heat in a house from a hundredweight of coal, when used for gas, was four or five times as great as for electricity. With regard to illumination the case was very different. Electricity and heat were changeable like a bank note and sovereigns. It was impossible to get more than the exact equivalent of heat in the shape of electricity or the exact equivalent of electricity in the shape of heat. There was no such rule in respect of illumination. Illumination depended on the temperature at which the heat was developed, and not on the quantity alone. One of the peculiarities of an electric current was that the whole of the heat could be wasted, or substantially the whole of it, in the smallest part of the circuit; that was the method of the incandescent electric lamp, in which it was made as difficult as possible for the electricity to pass through the lamp. In that case there was a very small bit of matter with a vast amount of heat expended upon it; there was a very high temperature, and a very large proportion of the heat went in the shape of light. In gas it was not possible to get a very high degree of temperature, because gas had to burn by the aid of the oxygen in the air. Air, one might say, consisted of five parts clinker and one part oxygen. Nitrogen must be looked upon as the universal clinker, and that was why it was not possible to get temperatures anything like so high with gas as with electricity, with its wonderful power of concentration of heat. He thought it was a piece of luck for gas that Von Welsbach hit upon the peculiarities of the rare earths, in that at the same temperature they would give out a vast amount more light than other bodies. How it could be so we did not understand a bit more now than at the time of its discovery, but it was so. While everyone could foresee that electricity would in years to come give a greater light than at its inception, by reason of improvements in lamps, no one could foresee the same thing for gas; and even now, when there had been great triumphs in connection with the rare earths in the incandescent gas mantle, there was no reason for thinking that it would ever be possible to get any further. He had appeared for all the electric companies when the first Bill came before Parliament, and he remembered Mr. Swann coming to him and asking whether in defence of the public something should not be inserted about the lamps used, and he told Mr. Swann: "If you are coming in the interests of the public, I would advise you to hold your tongue, because if you charge by the amount of electric energy all the improvements in lamps will go to the benefit of the public; but if you charge by light, improvements in the lamps will not benefit the public, but will benefit the companies." Whether he was doing his duty strictly to his clients he did not know, but Mr. Swann had appealed to him on behalf of the public, and he felt obliged to point out that there were limitless improvements possible in lamps, and therefore it was fairer that the companies should be paid according to the service they rendered, the amount of electric energy they furnished, and that the public should have the right to use it as economically as possible. The statistics in the paper justified these conclusions. Marvellous improvements had been made in the incandescent electric lamp. Stubborn substances which no one ever thought of using for the purpose, like tungsten and tantalum, had been made into threads of extraordinary fineness, capable of supporting very much higher temperatures and therefore giving a greater amount of light than carbon filaments with the same amount of energy, and those inventions had enabled electricity to give the same light at comparatively the same cost as incandescent gas mantles. Prior to that it was utterly beaten by the incandescent gas mantle. Early incandescent lamps were thought to be very good if they came up to 4 watts per candle-power, which was four times less than the ordinary lamp now used and eight times less than the half-watt lamp which had a comparatively limited use. Therefore electricity had divided the field with gas in illumination. He thought no one would doubt that the great waste of coal in a civilised country like England was its use in open fires, but was that going to continue? If it was, then the amount of coal saved by other methods would only go a little way towards making up for the waste in the open fires, but if it was desired to have an economical substitute for the open fire, gas left electricity entirely out of calculation. Gas would do the household service that the open fire used to do, and do it with great economy. Electricity was not comparable to gas in that service. It was very much the fault of the gas companies that they had not shown the public how best to use such a distributable fuel for the purpose of the open fire, whether for cooking or warming. Here was a great field in which gas had no competitor, and considering the importance to the household of distributing heat to take the place of open fires, the value to civilisation of using the energy of coal in the shape of gas could not be doubted. He had often noticed how the world, from time to time, went mad over some one thing. There was a time when all the pharmacopœia was considered to be summed up in tar water, which cured everything. People do not realise that panaceas do not exist in nature. Each thing had its own special properties and utilities, and the probability was that the higher civilisation would make use of very many means of accomplishing its aims, because its aims were so varied,

and it wanted to use each thing in the way in which its special utilities enabled it to be used. That was the lesson to be learned from the apparent rivalry of gas and electricity in rendering the coal as serviceable as possible to mankind. The one might be better under some circumstances, but the idea of the one driving out the other would be distinctly retrograde.

MR. F. W. GOODENOUGH thought that after the fascinating paper by Sir Dugald Clerk, and the illuminating remarks that had fallen from Lord Moulton, there remained very little to be said on the subject. He fancied all present must have had a vision of a bubble bursting as Sir Dugald read his paper—a bubble blown in public during the past few months for the delight of the housewives and householders of the country. He (Mr. Goodenough) felt that there would be very great disappointment in many hamlets, villages, and farms in the country at the disappearance of the vision of the supply of cheap electricity which was going to do everything in the direction of heating, cooking, and power, throughout the country. No legislature could possibly sanction measures to foster proposals that would lead to such a ghastly waste of the fuel resources of the country, limited as they were, as would be entailed by substituting electricity for the coal now used in our homes. This had been shown by the figures put before the Society by Sir Dugald. Might he (Mr. Goodenough) interpret those figures broadly? The quantity of coal used at the present time for domestic purposes in the country, Sir Dugald had spoken of as 36,000,000 tons; but a prominent official of the Coal Mines Department had stated that 40,000,000 tons about represented the consumption of crude coal for domestic purposes. Taking the Coal Controller's estimate of the gas equivalent required to replace coal for fuel purposes, gas could do the service of the householder that was done by the 40,000,000 tons of coal for a net destruction at the gasworks of 30,000,000 tons of coal, or, taking Sir Dugald's estimate as to the possibilities of gas production in the future, for the destruction of 20,000,000 tons of coal. But on the figures he quoted, it would take 120,000,000 tons of coal destroyed at the average generating station to-day to give equal service by electricity, or 60,000,000 tons with the thermal efficiency of something under 20 per cent. promised on behalf of the super-stations. When they bore in mind, too, that the use of coal at the generating stations would see the destruction of all the by-products that could be recovered if the coal were treated at the gasworks, electricity as the fuel of the future fell, he thought, still more completely to the ground. The figures Sir Dugald had given were borne out by practical experience, as for example by tests that he had made as to the relative work done by gas and electricity for cooking purposes. He had found that the practical cooking done by 100 units of electricity used in a modern cooker was equivalent to the work done by 1,000 cubic ft. of gas used in quite an old-fashioned gas-cooker. These figures would represent the net destruction of 75 lb. of coal at the gasworks, and of 300 lb. of coal at the average generating station of to-day; or 50 lb. of coal on the gas practice of the future, as against 150 lb. if the super-stations now proposed achieved their efficiency of nearly 20 per cent.

MR. W. H. PATCHELL suggested that the title of the paper might be amended to read "Distribution of Heat, Light, and Motive Power, by Gas and Electricity from the Thermal Point of View." Unfortunately coal was not the monetary standard of this country—and everything had to be looked at from the financial point of view. If the currency was in coal he would agree that the author had proved his case up to the hilt. Some of the figures required a little amendment, but the information given was most useful. If gas was so very superior to electricity for light, heat, and motive power, he would ask why electricity had been so very largely used for the purpose of driving the machinery upon which the winning of the war had depended. The production of gas had increased, but the factories had not been driven by gas but by electricity. When he heard people suggest taking small gas motors into the house he thought if they would only try it and see the difficulty there was in accommodating gas in factories, they would appreciate what they were up against. He used gas engines very largely himself. He did not look upon either gas or electricity as being a universal pill; he looked upon both as tools, and until partisanship was given up and people looked at both broadly as tools there would be very little possibility of getting very far. It was necessary to take whichever would serve the purpose best, and that purpose could only be served from the financial point of view. He would add that he was at present responsible for a large plant where power, light, and heat were required. The power and light were originally supplied partly by oil engines, partly by steam, and partly by anthracite producer-gas engines. The furnaces were heated in part by coal direct, and in part by anthracite gas. The whole of the coal now used was bituminous and was gasified in producers with sulphate of ammonia and tar recovery. The furnaces were heated by this gas, which was also used for engines driving dynamos which supplied the requirements for light and power. All the gas engines (3,000 h.p.) were provided with exhaust boilers, which supplied steam for the producers and for heating the workshops. If Sir Dugald Clerk, to whom we owed so much, could develop a large unit gas motor which would compete in capital cost per horse-power, in cost of housing, foundations, and in upkeep with the huge steam turbine units now available, he would add further lustre to his name. What hopes could he hold out of our getting such a desirable machine? Regarding the author's comparison of the production of power by gas with the best station quoted by

Mr. David Wilson, which operated on a thermal efficiency of 13·05 per cent., it must be remembered that 13 per cent. was not by any means the limit of the efficiency of a steam plant. Mr. Alexander Dow, in a paper read before the American Electro-Chemical Society, at Pittsburg, in October 1917, gave operating figures for two years of Connor's Quay Generating Power Station at Detroit. These figures were based on the actual output from the station. The British thermal units per kilowatt hour, for the year ending June 30th, 1916, were 19,700, and for the year ending June 30th, 1917, 20,040. The figures showed an overall efficiency of 17·35 per cent. and 17·0 per cent. respectively. The lower figure for the latter year was due to one of the turbines working without its last row of blades. In considering the figures it must be borne in mind that the generating sets at Connor's Quay were 25,000 k.v.a., and the steam pressure only 225 lb., and that the station was not provided with economisers. Guarantee figures for new machines lately put into commission showed an efficiency of 24 per cent., which, with a boiler efficiency of 80 per cent., would give an overall efficiency of 19 per cent.

Professor W. E. Dalby, F.R.S., after paying a tribute to the immense amount of work involved in the preparation of the paper they had just listened to, said that the many intricate problems of power distribution would in the future be solved not by depending on one form of energy transmission alone, but by using the form best adapted to meet the conditions of special problems. There was a good deal of popular misapprehension regarding electricity and its place and influence in our national life. It was not sufficiently recognised outside the profession that electricity was not a means of producing power, but only a means of transmitting power produced by the consumption of coal, or gas, or the power of a waterfall. Mechanical energy was produced centrally, and mechanical energy was used locally and electric transmission was the belt between the central station and the local factory. Lord Moulton had referred to a newspaper article in which the impression was given that the United States Navy was henceforth to be driven by electricity. Coal, engines, and boilers were done away with. Technical men knew well enough that what was meant was merely an electric connection between steam-driven turbines and the propeller. No one to-day would put up a factory without electric driving, but whether it was advisable in all cases to produce the mechanical energy at a central station far from the factory and transmit it electrically, or whether it would be preferable to produce the mechanical energy in the factory itself, and so reduce the problem of transmission to that of sending power from the engine-room in the factory to the machinery in the factory was for many conditions an open question. It had been a great pleasure to hear Lord Moulton's speech on the general problems of electricity *versus* gas, particularly his references to the political aspect of the matter.

General E. H. Hills, C.M.G., F.R.S., said he understood all the figures given by the author were based upon the ordinary town gas as supplied at present, and he should like to know whether there was not a possibility of a very large improvement if the idea was abandoned of gas requiring to be, *per se*, an illuminating agent. Some steps had been taken in that direction, but in the future heating gas would be needed, not illuminating gas. Would it not be possible to supply the public with some form of producer-gas which had by itself no illuminating power, but which could be used with a mantle? If that could be done, gas could be supplied at a fraction of its present cost, and it would come into use very extensively. The community of the future would require a supply of electricity and of gas, electricity for lighting and small power units, and gas for cooking and heating, and possibly in some cases for lighting.

Colonel R. E. B. Crompton, C.B., said the paper reminded him of the great controversy which was started forty years ago in the Room of the Society. The controversy at present was very much on the same lines as it was then. In dealing with the question of merits it was to be regretted that some people were violently in favour of gas, and electrical people were strong on electricity. Since then electricity had grown up. It was perfectly true, as the Chairman had said, that the idea of a world without coal was a horrible prospect for the human race, and it would be particularly so for a man who had reached the age when bodily heat was of great importance to him. He himself was approaching that age, and could now sympathise with the cottager who cowered over his small fire in his cottage, and he wanted to give that cottager an electric radiator to comfort him, with less units of coal burnt than were burnt in the open fire. To live comfortably people did not require heat by convection; they did not want hot rooms, but something resembling sunlight, and the radiating power of the sun could be imitated to some extent by the electric radiator, but not by any gas radiator he had ever seen. However efficient a gas radiator, it had to be put at the side of the room in order to get away the products, whereas the portable radiator could be taken to any place required, even to the bedside. The ration schedule fixed by the late Coal Controller was a fair schedule, and everybody who looked into his bills for electricity and gas during the present year would find that it was fairly framed on the basis of the 800 units of electricity against the 15,000 ft. of gas. In that schedule was taken into consideration the great convenience of using the electricity supply in extremely small units, either for heat, or

for power, or for light. The bill for the distribution of electricity would be an immense boon to the rural population, and he did not think the amount of coal consumed would be great, because it would be economically used.

Sir Dugald Clerk, in replying to the discussion, said he was much indebted to Lord Moulton for his admirable remarks and for the most useful summary he had given of the methods of transmission of energy. He hoped his friend Mr. Patchell did not think for one moment that he was underrating the very important services that had been rendered to the world by electricity. He had made it quite clear in the paper that he was dealing with the thermal aspect of the question. He dealt with that because official reports seemed to infer that by distributing electricity there would be a saving of coal, and he wished to warn the country of the danger of that supposition. He had carefully taken out the efficiencies of the various uses. As Lord Moulton had pointed out, electricity was admirably suited for lighting and for power. The difficulty was that in cases where higher thermal efficiency was required, electricity did not give the same efficiency that could be obtained with an ordinary gas-engine plant. He quite agreed with Mr. Patchell that there were many situations where it was more convenient to put in an electric motor. Even in places where gas motors were used, electric motors were used for driving cranes and other purposes, and in the works with which he was connected, where they made nothing but gas engines and internal-combustion engines, the works were lighted by electricity, and the cranes and machines were driven electrically. Electricity was a method of transmitting power from the generator to the place where it was to be used. If Mr. Patchell dealt with the financial aspect, he would find the case for electricity worse. Gas was a far more economical source of energy both of light and heat. If it had to be decided on relative cost, he thought electricity would disappear in many of its uses. At present it was cheap enough for many uses, and indispensable for others. He agreed with Professor Dalby as to the value of electricity. As things became more complex there was a tendency of the human mind towards unification. Every man was apt to think that the particular part of science or industry with which he dealt was the leading one. With regard to gas as an illuminating agent, as spoken of by General Hills, he was glad to say that that was the direction in which the gas industry was moving. Fifteen or sixteen years ago he had said at the Gas Institute pretty much what General Hills had said, that the intrinsic illuminating power of gas had become, by the invention of incandescent gas, really a matter of very little moment. That had been gradually enforced on the general public, and in the use of gas in the future there was no doubt it would be far better to have a non-illuminating gas, with a sufficient supply of thermal units to heat up the rare earths of which Lord Moulton had spoken. He sympathised with his old friend Colonel Crompton's point about old men needing heat, and agreed that the electric radiator was a very useful thing when a man was old or ill, and had the very great advantage of being able to be moved about, and so brought close to wherever it was wanted. But it should be remembered that there was only room for one or two people round the radiator. A very great debt was owing to electricians, and electricity was and would be always required. What he was protesting against was the general campaign for the condemnation of other sources of energy. Gas people were perfectly willing to compete in a friendly way with electricians, and he thought electricians were ready to compete with gas men, if the politician would not interfere too much.

Mr. W. H. Massey proposed a vote of thanks to the author for his most interesting and valuable paper. The Chairman, he said, was the greatest living authority on Patent Law, and the author was a very eminent expert, and he should like to know how, even if they put their heads together, they would find it possible to distribute heat, light, and motive power. In his opinion the title of the paper should have been "The Distribution of Gas and Electrons for Heating, Lighting and Driving Purposes."

The vote of thanks was carried unanimously.

A vote of thanks to the Chairman concluded the meeting.

VEGETABLE-OIL INDUSTRY IN SÃO PAULO.

Of the industries which have been developed as a result of the war, none has had a more striking growth in the São Paulo district than the manufacture of vegetable oils, and as a result this State, which formerly imported large quantities of such oils, is now not only equipped to supply its own requirements of most oils, but is beginning to export in quantities that will increase as the extensions of the oil-mills planned are carried out.

The most notable increase has been in the production of cottonseed oil. The establishment of this industry indicates not only that the local market will be lost to the foreign exporter, but that the São Paulo mills will compete against the foreign product in other South American markets. The manufacture of cottonseed oil was begun towards the end of 1915 by one mill, which produced oil suitable for culinary purposes and for the manufacture of soap. This mill passed through an experimental stage, owing to the fact that the owners had not secured expert help to select the machinery or to run the mill. Its difficulties have been satisfactorily solved, however, so far as the mill itself is concerned, but some trouble has been encountered in obtaining good milling seed.

Plenty of cotton is raised in the State of São

Paulo, but some of the fields are remote from gins, and the unbaled cotton is frequently exposed to heavy rains before being ginned, so that the seeds absorb much moisture. Perhaps not so much damage is done to the seed before ginning as afterwards, for the industry is so new that the planters have not yet learned to protect properly seed that formerly was merely so much waste. Consequently, the seed is generally permitted to lie in unprotected heaps until it begins to mould. This condition is not helped by the long delays in transit which the seed has frequently to suffer. But the farmers are rapidly learning that the seed is valuable, and it is expected that there will soon be a great improvement.

In 1916 another company in São Paulo decided to undertake the manufacture of oil, employing an American expert and American machinery. The product of this mill, which began its operations in 1917, is of the very highest grade. Large shipments have been made to the Argentine, and the only impediment to the rapid expansion of the trade is the difficulty in getting seed and in obtaining material for the manufacture of containers.

The war has developed a heavy demand for castor oil for aeroplane-motor lubrication. Consequently, the despised castor bean, which has been regarded as something of a nuisance in the State heretofore on account of its persistence, has become a valuable resource, and is being harvested wherever it can be found. It grows in nearly all cultivated land with a vigour and tenacity comparable only to that of the most common native weeds. Wherever it is introduced in the State it is almost impossible to eradicate it; it appears in the open spaces about the houses, in the midst of the growing crops, and in the fields after the harvests, or even in the new lands from which the forests have just been cleared, and in old pasture lands.

Hitherto regarded as a pest, little attention has been paid to the plant. It was thought that it might eventually become more valuable for its fibre (for the manufacture of cordage), and for its leaves (which are said to be excellent food for silkworms) than for its oil. A few small mills throughout the State worked the beans to produce oil for sale in the backwoods districts, where it is used to a certain extent for illuminating purposes, for soapmaking, and as a lubricant.

The demand for the oil has now reached a point where the call is far in excess of the producing capacity of the mills, and many American manufacturers are importing the beans to crush in their own mills. There are four small mills in the city of São Paulo.

Linseed oil has been imported almost exclusively from the United Kingdom and Argentina up to now. However, a considerable amount of flax is being grown in the States to the south of São Paulo, and the oil mills in that city are, writes the United States Consul there, making preparations to treat the seed, it being believed that the same machinery can be adapted to the crushing of several different kinds of seeds, such as castor beans, linseed, and peanuts.

Peanuts, called "amendoim" in Portuguese, grow in São Paulo with almost the same vigour as do the castor beans, and the mills will handle them, it is expected, with the same machinery that is used for other seeds. It is thought that the unlimited supply, which is obtainable for at least six months in the year, will enable the millers to produce oil in such quantities and at such low prices, that the product will force itself on the market, although but little is used as yet.

The forests of the State of São Paulo produce an immense variety of oil-bearing nuts. The cashew nut is, perhaps, the best known of these, but others are equally valuable for their oil. One, called the "ucuba" nut is 60 per cent. vegetable tallow, and another, called the "babasu," also contains 60 per cent. of oil. A babasu nut will burn for half an hour if a lighted match is put to it. Its kernel is much like copra and is excellent for soap-making.

SHOE-MANUFACTURING IN THE PHILIPPINES.

People with the skill and patience to weave transparent cloths by hand, beat old Spanish coins into fine table silver and jewellery, embroider minute figures on the finest silk, weave rattan furniture superior to the best found anywhere else in the world, and do other work quite as exacting in its demands for patience and preciseness, can well be expected to make fine footwear when shown how and given proper materials. These people are the Filipinos, and the quality of the Philippine product surprises those who see it for the first time.

According to a report by the United States Commercial Agent at Manila, the important native shoemaking district is Mariquina, a few miles from Manila. There the uppers are cut, skived, and folded by hand, and the deftness of the women who do the work certainly commands admiration. The skiving is particularly fine, the cut being made at as true an angle and as uniform in width as if it were made by machine. The sewing of the uppers is the only machine work entering into the manufacturing process. The making-room work is done by hand, and is performed by natives, who finish about three pairs in two days.

The materials used in Mariquina are American calf, black and tan, and carabao, or vaca sole leather, native tanned. These sole leathers, especially the carabao, have an odour, for they are tanned with camanchile bark, the liquor of which ferments very quickly and smells somewhat worse than crushed wattle seed. It is not at all water-resisting unless waterproofed, and it is seldom so treated by the natives. It makes a splendid insole, however, barring the odour, which probably wears off after a while.

On account of the lack of locally-made light leathers, these shoes are usually quarter-lined with

imitation leather. Small pieces of the upper stock are often pieced together to make the tongues. The stiffeners, shanks, and heels are all made from the sole-leather offal. Lacking pressure machinery, the bottom finish is irregular.

The Mariquina shoes are usually made on contract for Chinese merchants, who furnish the materials. The women receive from 75 cents to 1 dollar per dozen for making the uppers, and the men receive about 65 cents a pair for their part of the work. The shoes are sold at wholesale for about 2 dollars 25 cents (say 9*s.*) a pair.

It is from these Mariquina shoemaking establishments that the two American factories get most of their operatives. The two factories are both in Manila, and have a combined capacity of about 500 pairs a day. Sixty pairs a day is the largest reported capacity for a native shop. With the exception of native footwear for women and children, only men's shoes are produced in the islands. The two companies working the above-mentioned factories both export their products to the Dutch East Indies and various Oriental markets.

It is quite possible, adds the United States Commercial Agent, that exports of Philippine footwear will some day be an important item in the island's commerce, especially if the tanners make use of their opportunities in the way of raw hides and a plentiful bark supply, and attain an adequate output of both upper and sole leathers in desirable qualities, for these factories have proved that they can make shoes and make them well.

THE COCONUT INDUSTRY IN BRAZIL.

The coconut zone of Brazil fringes the coast from Parahyba on the north to Bahia on the south. This zone is dotted with coconut groves, varying in size from a few hundred trees to 40,000. The total number of bearing trees approximates to 1,250,000. The annual yield per tree is forty, or a total annual production of 50,000,000 nuts. The average size of the nuts compares well with the products of other tropical countries, 5,000 nuts being required per ton of copra.

There are three ports from which the coconuts are shipped, viz., Cabedello, Recife (Pernambuco), and Maceió. About three-fourths of the coconut trees are concentrated around Cabedello and Maceió.

The price paid on the plantation for nuts varies with their size and their distance from the cities. The largest nuts command £7 per thousand, while the smaller ones are sold for £5 per thousand. The average selling price on the city market is £8 10*s.* per thousand.

According to information supplied to the United States Consulate at Pernambuco by Mr. A. J. Brooks, an American who visited Brazil to investigate the coconut industry, no attempt beyond the experimental stage has been made to produce copra. The reason for this is the result of local conditions, namely, the limited number of available coconuts and the native's fondness for the nut as a table delicacy. With copra selling in New York at £32 a ton, and freight averaging £2 a ton, the plantation owner makes ½*d.* more profit on every coconut he sells on the local market than if he had turned that coconut into copra. This statement does not mean that copra cannot be produced in Brazil at a profit. On the contrary, there is excellent opportunity, in Mr. Brooks's opinion, for capital to operate a coconut grove and sell copra at a good margin of profit if a working organisation were effected, if the other products of the tree were utilised, and if the available space were cultivated with catch crops.

The possibilities of the coconut industry in Brazil are tremendous. The annual yield per tree at present is forty nuts, as already mentioned, despite the fact that many of the trees are robbed of their fruit before the meat begins to form, to be sold upon the local market for their milk. This practice has appreciably lowered the vitality of the trees. Seed selection has been almost entirely neglected, and fertilisation is a science never practised.

Improper spacing is another existing evil which contributes to the retarding forces so prevalent in the Brazilian coconut groves. This is strikingly depicted in the case of two adjoining groves of the same age, one planted with seventy-five trees to the acre and the other with one hundred and thirty trees. The annual yield of the former is four times that of the latter. Disease and pests are almost unknown, and labour is cheap.

The possibilities of disposing of the by-products are excellent. The fibre would find a waiting market in the form of cord or rope; the husk would sell readily for fuel; the milk is always sought by the native for his familiar breakfast food, the "cuscoos"; and the palm leaves are eagerly bought by the natives for building purposes.

GENERAL NOTES.

Exports during the War.—A recent report of the American Bureau of Research shows that of about twenty commodities reaching a total of over £4,000,000 each exported from the United Kingdom in 1912 or 1913, only two have not decreased—(1) arms, ammunition, military and naval supplies, and (2) woollen tissues. This country has for many years held the leadership in the manufacture and export of cotton piece goods. In 1913 the United States exports for all cotton cloths was only one-sixteenth that of Great Britain. "Since the war began, Britain's huge exports have slumped to two-thirds of their former amount, while those for the United States have increased by over 50 per cent. The United Kingdom exports to France have increased very much, but the quantities sent to nearly every other country have

decreased greatly." What is true of cotton piece goods in general is true of most of the different varieties or sub-classes. Of woollen goods, the report says that in 1913 the total value of this class of domestic exports from the United Kingdom was 47 million dollars, but in 1917 this had fallen to 37 million dollars, and in the first half of 1918 it was less than 17 million dollars; this in spite of the rapidly-increasing prices. The United Kingdom export of "new iron and steel rails" had fallen from over half a million tons in 1913 to less than 16,000 tons in the first six months of 1918. The once large exports that went to South America (especially Argentine Republic), British India, Australia, and Africa, have all but ceased. The United States exported about 90 per cent. as great a tonnage of rails in 1913 as did the United Kingdom. There was a great decrease in the fiscal year 1914, and in 1915 the total was not greatly over a third of that for 1913. But the next three years brought large sales to France and Russia and great increases to Canada and Cuba. The totals in 1916 and 1917 far surpassed previous records, but that of 1918 was hardly equal to that of 1913.

VICTORIA AND ALBERT MUSEUM.—A collection of specimens of cotton-printing, chiefly of the eighteenth century, has been acquired by the Victoria and Albert Museum. The collection, which numbers about 350 pieces, is considered to be of special value to designers and students. A selection has been temporarily arranged in the class-room of the department, and the others may be seen on application at the students' room.

PETROLEUM FUEL OIL.—Reviewing the official statistics, the *Economist* mentions that in 1912 we purchased 48 million gallons of petroleum oil fuel at a cost of £48,000. In 1916 our total supplies fell to about 23 million gallons, but rose to 441 millions in 1917, and to 842 millions in 1918, costing us in the latter year £23,984,500. For 1912 four countries—the United States of America, Mexico, Rumania, and Dutch Borneo—are enumerated as the sources of supply. In 1913 Persia and British India were added. In 1916 and 1917 only the United States and Mexico sent appreciable supplies, but from both we received greatly increased quantities.

IRRIGATION IN INDIA.—In the course of his Budget speech at Delhi on March 1st, Sir James Meston, Finance Member of the Governor-General's Council, gave some interesting information about the great irrigation undertakings of the Raj. The total length of main and branch canals and distributories from which irrigation was done during the year 1917-18 aggregated nearly 65,500 miles, a length which will have been increased by some 700 miles before the current financial year closes. These channels irrigated last year an area of 25¾ million acres out of a total culturable commanded area of about double that extent. The area irrigated during the current year is expected to fall short of that realised in 1917-18 by about a million and a quarter acres as a result of the serious deficiency in the rainfall. The operations of the recently completed triple canal system in the Punjab continue to expand. About 1,200,000 acres of crops were brought to maturing in 1917-18, and a further increase of 100,000 acres is anticipated during the present financial year. These results, he said, are extremely satisfactory, as the system was only declared complete on March 31st, 1917. Besides the canals actually in operation, there are 34 major works—new systems or adjuncts of existing ones—which are either under construction, awaiting sanction, or being examined by the professional advisers of the Government of India and of local governments. It has been roughly computed that if they are all undertaken they will extend the benefits of irrigation to an additional area of about 11 million acres a year. They are estimated to cost £32 million sterling and to produce a net revenue of nearly £2½ millions.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

APRIL 30.—SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 7.—JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 14.—H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom." MAJOR-GENERAL SIR PHILIP NASH, K.C.M.G., C.B., will preside.

MAY 21.—SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Japanese Design."

MAY 28.—HARRY J. POWELL, "Glass-making before and during the War."

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.:—

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies in India, with special reference to Indigo." SIR WILLIAM DUKE, G.C.I.E., K.C.S.I., will preside.

Dates to be hereafter announced:—

BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

SANDFORD J. KILBY, "Indian Salt Manufacture."

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 5,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—April 18, 1919.

No. 3466. APRIL 25, 1919. Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,466. VOL. LXVII.

FRIDAY, APRIL 25, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK.

WEDNESDAY, APRIL 30th, at 4.30 p.m. (Ordinary Meeting.) SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

The lecture will be illustrated with experiments.

Further particulars of the Society's meetings will be found at the end of this number.

PROCEEDINGS OF THE SOCIETY.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 26th, 1919; Mr. A. A. CAMPBELL SWINTON, F.R.S., M.Inst.C.E., M.I.E.E., in the chair.

The paper read was—

BRITISH ENGINEERING AND WATER-POWER DEVELOPMENT
(The Training of Engineers).

By PROFESSOR A. H. GIBSON, D.Sc., M.Inst.C.E., M.I.Mech.E.,

Professor of Engineering in the University of St. Andrews at University College, Dundee.

Historically considered, the utilisation of a country's power resources has passed through three more or less distinct phases. The first was rendered possible by the invention of the water wheel, and led to the grouping of the early manufacturing communities around easily available water-power sites.

The invention and development of the steam engine ushered in the second period. The utilisation of coal as a source of power rendered the proximity of water powers no longer an important factor, and industrial communities developed wherever the supply of raw material and of fuel, with labour, markets, and transport facilities were most easily assured.

The third phase followed on the development of the electric generator and of the possibility of high-voltage electric transmission. This by permitting of the development of water or steam power at the most economical and convenient sites, and its transmission to the most convenient point for its utilisation, has called for a revaluation of our sources of energy. The size of the power-plant is no longer limited to the requirements of a single user; and the power for an entire community may be developed at a single-power site, and by one or two units.

The tremendous advance of recent years in the applications of electric power in industry, in electro-chemical and metallurgical processes, and the development of such processes as are utilised in the manufacture of carbide, cyanamide, the alkalies, aluminium, and carborundum, for example, all of which require relatively huge amounts of cheap power for commercial success, has accentuated the progress of this last stage.

Under the stimulus of the demand for such powers, the investigation of the possibilities of water-power resources has proceeded rapidly, during the past decade, in those industrial countries favoured with suitable sites, and not so favoured as our own with an abundance of cheap fuel.

The demand led to the development of large and efficient water turbines direct coupled to electric generators, and the extent to which this has been successful will be realised in view of the fact that specifications have recently been issued for a series of turbines to develop 52,500 h.p. each, at one installation on the Niagara River, while subsequent units of the same plant are intended to develop 100,000 h.p.

Possibly because of the abundance of cheap fuel, and of the relatively limited possibilities

of obtaining water-power on any large scale in close proximity to our industrial communities, the question of the development and utilisation of water-power, has, in the past, been treated as of very minor importance in this country, and it is only within the last two or three years that this question has shown signs of receiving the organised attention which is warranted by its importance.

As one result of this interest, a Water Power Committee was appointed in 1917, by the Conjoint Board of Scientific Societies, to report upon the general state of investigation into the water-power resources of the British Empire. The data collected by this Committee, under the chairmanship of Sir Dugald Clerk, show that the potential water-power of the Empire is enormous, and while it is impossible to give even approximate figures as to the possibilities of many of the self-governing dominions and dependencies, a conservative estimate places the commercially available water-power of the Empire at between fifty and seventy million continuous horse-power.

When it is realised that the total industrial requirements of the world at present, excluding shipping, only amount to about ninety-five million horse-power, involving, however, under present conditions, the consumption of some 600 million tons of coal per annum, and, moreover, that this is not continuous power, but is in general only utilised for some 3,000 hours per annum, it is evident that the water-power of the Empire, if efficiently utilised, would be sufficient in amount to perform the major portion of the world's industrial work, and that this water-power is bound in the future to be a powerful factor in determining the economic destiny of the Empire.

The growing interest in British water-power has been shown by the appointment, in 1918, of a Board of Trade Committee with instructions to investigate the water-power resources of these islands. This Committee, under the chairmanship of Sir John Snell, has already investigated and carried out preliminary surveys of several schemes in the Scottish Highlands and in Wales, with results which show that, even in this country, several large schemes are commercially feasible, and which indicate that the aggregate water-power of the British Isles is likely to prove somewhat surprisingly large.

Late though it may be, this arising of interest is welcome. During the past decade there has been unprecedented attention paid in most of the other civilised countries of the world to this question of hydro-electric development, and particularly in the U.S.A., Canada, Norway and Sweden, Italy, France, Germany, and Switzerland, many large projects have been completed or are in progress or active investigation.

In France alone some 850,000 h.p. has been put into operation or into development since 1915. In Italy, concessions involving some 300,000 h.p. are already under way, or are being considered. In Iceland, one scheme involving the development of over 1,000,000 h.p. is in contemplation. In Spain various large projects, including one estimated to give some 350,000 h.p., are under consideration. In Japan many projects are in course of development. In Austria and Russia, in spite of the disturbed conditions, considerable attention is, according to all reports, being paid to hydro-electric developments, particularly in the former country, with reference to the electrification of railways.

In many of our Dominions and Dependencies, too, the question is arousing much interest. In Canada and New Zealand the importance of water-power has long been appreciated, and probably no country in the world is more progressive in this respect than is Canada, with its development of some 2,300,000 h.p. Many large schemes have also been developed in India, Ceylon, and Tasmania, while in these latter countries, as also in Australia, South and East Africa, and British Guiana, investigation committees of one form or another have been, or are being formed to obtain definite data as to the true possibilities of the situation.

As a result of all this interest and investigation, it is certain that in the near future a very large amount of hydro-electric development will be undertaken throughout the world, and that large amounts of capital will be expended in the various branches of engineering directly interested in such work.

The cost of developing water-power depends very largely on the physical characteristics of the site and on its distance from the nearest market. It may be as low as £10 per horse-power in very exceptional cases, while a capital cost as high as £60 per horse-power may not be prohibitive where coal is dear. A recent analysis of the returns from seventy representative hydro-electric stations in Canada, aggregating 746,000 h.p., shows an average total construction cost of £14 2*s.* per b.h.p. This does not include cost of land or of transmission and distribution. In New Zealand the estimated cost of developing a large number of schemes,

aggregating 3,800,000 h.p., including transmission, averaged £31 per horse-power before the war, while in Great Britain the average cost of such large schemes as have been investigated is about £40 per horse-power. In any case, the capital expenditure for a development running into millions of horse-power must be extremely large, and it becomes a matter of urgent importance as to whether this capital is to be expended for the furtherance of British or of foreign industry.

It must be admitted that until quite recently British engineers have, with few exceptions, taken little interest, either financially or from a manufacturing standpoint, in hydro-electric developments, particularly in those on a large scale, and this relative lack of interest has had an adverse effect, which has been cumulative, as regards the position of the hydro-electric industry in this country.

Few engineering problems demand a more general knowledge than those presented in the development of a water-power scheme. The engineer has to deal with a whole series of civil engineering problems, including rainfall and run off data, gauging operations, the survey and contouring of catchment areas, the construction and foundation of dams; the construction and lay out of pipe lines and pipe tracks, culverts, pressure tunnels and surge tanks, power houses, and regulating sluices: with a series of mechanical and electrical engineering problems, involved in the arrangement and regulation of hydraulic and electrical machinery, and the installation and operation of transformers, transmission lines and sub-stations. Since the chance of the commercial development of any scheme depends essentially on the possibility of obtaining a profitable outlet for the power, the engineer should have a sound, if not detailed knowledge of modern electro-chemical, physical and metallurgical processes, and, in general, of the many branches of industry in which cheap electrical power is an essential.

In some aspects the required training needs to be on broader lines than in almost any other branch of engineering. On the other hand, many of the problems involved are extremely specialised, and require an intensive scientific training, along with such knowledge and experience as can only be gained by actual contact with the design, manufacture, and operation of such installations.

Under these circumstances, it will readily be understood that the experience gained on the Continent of Europe, and in Canada and the U.S.A., has offered facilities for the training of experts in hydro-electrical engineering which have in the past been very limited in this country. It would be untrue to say that such facilities have been entirely lacking, since the Kinlochleven plant of the British Aluminium Company, with its 30,000 h.p. installation, which has been in operation since 1909, affords many interesting object lessons, and has aroused much interest among foreign engineers. There are also now two comparatively large high-head installations in North Wales, and a number of low-head municipal supply plants, such as Chester and Worcester, which, though small, are worthy of study.

Still, the facilities for obtaining practical experience in hydro-electrical engineering in this country on large-scale plants have been relatively small, while the facilities for obtaining specialised scientific training have been to all intents and purposes non-existent. It is true that the engineering schools, in most of our universities and technical institutes, devote some attention to the study of hydraulics, though with one or two exceptions the subject is treated as of minor importance, compared with, say, the study of steam engineering. Also, courses in electrical engineering are provided in the majority of such institutions. But in no case as yet has an attempt been made to give such a definite course of training in the specialised problems facing the hydro-electric engineer, as is done, for example, in such institutions as Cornell and McGill Universities, and in many of the Continental technical institutions.

It would be unfair to attribute this neglect in the past wholly, or indeed mainly, to our universities. The initiation of such a course as is necessary involves the appointment of highly paid specialist lecturers, and the expenditure of considerable sums in equipment, and in the past the provision of the necessary funds from the resources available to the universities has been impossible. The State and municipal grants which have enabled the universities of the Continent and, to a smaller extent, of the U.S.A., to develop to their present status have been and, indeed at the moment of speaking, are negligibly small in this country. Moreover, the external stimulus for the initiation of such courses has, in the past, been lacking. The number of openings available for the young engineer, trained in general civil, mechanical, or electrical engineering, is large, and there has been a general demand for such courses. On the other hand, the number of openings in this

country for the specialist hydro-electric engineer has in the past been small, owing to the comparatively small number of manufacturing or consulting firms actively interested in this branch of engineering. Conversely, when such firms have required trained engineers, they have been forced in the majority of cases to go to America, Canada, or more commonly to Sweden, Germany or Switzerland. As an almost inevitable consequence, the design and manufacture of the hydro-electric machinery, including the turbines and generators, have been entrusted to some Continental firm, and of the few really large hydro-electric installations for which British establishments have been responsible, the greater part of the hydraulic machinery has been made abroad. It is true that British engineers are available whose specialised training in hydro-electric engineering leaves nothing to be desired, and who are competent to undertake the development of any scheme, but the number of such engineers is very small.

That this state of affairs is unsatisfactory requires no emphasis. And until it is radically altered, and until the whole of the work of investigation, design, manufacture, installation, utilisation, and supervision can be carried out successfully by British engineers in adequate numbers, the situation will remain unsatisfactory. This is a point which does not require labouring. The question is what action is necessary to improve matters.

There can be no doubt as to the capacity of British engineering to deal satisfactorily with all the manufacturing and civil engineering difficulties. Given the designs, the manufacture of the large hydraulic turbine is a comparatively simple proposition, and involves no process which any firm used to the manufacture and machining of large castings could not carry out with perfect success. Probably no engineers in the world are better equipped than our own to carry out with success the purely civil work involved. The electrical work also involves no special manufacturing problems. In short, given engineers with the required specialised knowledge of design in all branches, there is no engineering reason why any installation should not be initiated, designed, and built in the country at the present time.

The primary necessity would appear to be the formation of some strong financial corporation or combination, primarily and aggressively interested in the development of water-powers. This might be an independent financial body, or, alternatively, a combination of engineering firms dealing with the various manufacturing sections. The existing turbine manufacturers in this country might readily form the nucleus of such a combination as regards the hydraulic side.

This corporation would probably find it possible to form an advisory and scientific nucleus of British engineers, which might, if necessary, be augmented and strengthened by Canadian experts. Incidentally a close co-operation between Canadian and British manufacturing firms would probably offer many mutual advantages.

Once having entered fairly into the hydro-electric field the possibility of completing the training of a supply of engineers by actual experience in the field and in the operation of plants would soon become a simple matter.

In the meantime immediate steps should be taken for giving such engineers an opportunity of obtaining a scientific training in the fundamental principles of their profession.

For this the institution of special courses in our universities or technical institutes would appear to be essential. Reference has been made to the necessary breadth of the successful hydro-electrical engineer's training, and, as a preliminary, the ordinary engineering course, as now given in the majority of such institutions, would appear to be suitable. But in addition to this, special work relative to the design and operation of turbines; the design and arrangement of pipe lines and surge tanks; the design and operation of large generators, transformers and transmission lines; and the utilisation of power for such purposes as electric traction, the manufacture of aluminium, carbide, cyanamide, and nitrates; for electro-metallurgical processes, and for pulping plants, should be included. This would almost of necessity involve a special post-graduate course of study, and should be accompanied by visits to all available hydro-electric stations. It would also be advisable that the course should include a period of work in some such station.

After completion of this course a year or so in works and on erection, with a further year or two of work in some drawing office and estimating department, would produce an engineer with every chance of undertaking responsible work with success. Pending the provision of such courses in this country, the provision of a few travelling scholarships, to enable suitable men to attend courses in Canada or the U.S.A., would do much to relieve the probable early demand for trained engineers.

Whether such training should be developed

in some one specially designed and equipped institution, or whether the engineering schools of our existing universities should be extended and strengthened, is a matter of opinion. As the preliminary part of the training is of a general nature such as is already provided by these institutions, there are some advantages in adopting the latter course, and by choosing suitable institutions, if possible not too far from existing hydro-electric plants, the problem could be solved with every prospect of success. For this purpose the universities on the east and west coasts of Scotland and the University of North Wales would appear to be well placed, and it is certain that, given the necessary financial assistance, such universities and technical institutes would be only too willing to carry out the work.

On the other hand, the provision of a special institution with facilities for carrying out full-scale tests and investigations on the largest scale would be of enormous value, and, even if only supplementary to other institutions, the provision of such plant should be considered. Probably this could best be arranged in close connection with, and forming part of one of the hydro-electric installations at present in existence or in course of investigation. This, then, would require to be situate either in Scotland or North Wales. In either case its remote situation would render it somewhat inconvenient as the site of a large engineering school, although this objection is possibly not serious.

Whichever system might be adopted as most satisfactory, it could only be carried to a successful conclusion by the co-operation of all interested in hydro-electric plant and its auxiliaries. The number of industries vitally interested in the matter is large. Excluding the civil engineering and structural works, makers of turbines, pipe lines and valves, electric generators, transformers and transmission lines are all affected. Although, indeed, the turbine forms the focus of the whole system, the cost of the turbine itself usually only accounts for a very small fraction of the total cost—seldom more than some 5 or 6 per cent. and usually much less than this—and from the purely financial and manufacturing point of view, the manufacturers of cement, civil engineering plant, structural members, pipe lines, valves, electrical machinery, and cables, stand to gain much more by such developments than do the makers of turbines.

While the provision of a special hydro-electric establishment would be costly, the outlay would probably be returned indirectly many fold within a few years. If so designed as to be capable of dealing with acceptance and efficiency tests of very large units the data obtained would be invaluable, and the resultant testing fees should ultimately render it to a large extent self-supporting.

It is suggested that the pros and cons might with advantage be considered by a committee of the leading firms interested or likely to be interested in such a project, and of the Department of Scientific and Industrial Research. It is probable that as the outcome of such a conference, little difficulty would be experienced in arranging the question of ways and means.

Perhaps it is not too much to hope that in the near future the provision of such an institution and of such courses as have been suggested may become an accomplished fact. When it does it will be a significant sign that British engineering is willing, prepared, and able to take its full share in the development of the world's water-power resources.

DISCUSSION.

The Chairman (Mr. Campbell Swinton) said that although Professor Gibson's paper was a short one, all would agree that it was very suggestive, and contained not a few matters on which there might perhaps be various opinions. In one place he said it must be admitted that until recently British engineers, with few exceptions, had taken little interest in hydraulic development. Perhaps a little bit of history which the speaker proposed to tell might not be known to all present. In 1903–4 there was started in this country a small syndicate containing one or two engineers. It was originally started by the late Mr. Emanuel Ristori, who was one of the original founders of the British Aluminium Company. They—the speaker himself was a member of that syndicate, which also included Mr. Vaux Graham—investigated at that time practically all the large water-powers that were to be found in Great Britain, chiefly in Scotland. The trouble was that, although there were a large number of them, there seemed to be no prospect of bringing them into use with any sufficient financial result to attract the necessary capital. At that period coal was fairly cheap, and if one attempted to bring water-power from the Highlands to the manufacturing districts of Scotland, the advantage to be obtained over what could be done locally by means of coal was quite insufficient at that time to give an attractive financial return. Then, again, at that period aluminium was practically the only electro-chemical product that was being produced on a large scale; it was then being sold at rather less than cost price, because the ring which had

previously existed, and had kept the price of aluminium up had been dissolved, the British Aluminium Company had just gone into liquidation, and aluminium was not a thing which any financial person would touch. He only mentioned all this to point out that he did not think it was quite fair to suggest that the reason why the water-powers had not been developed in this country was the fault of the engineers. It was due to the circumstances, particularly the cheap coal, and the condition of the electro-chemical trade. There was really no demand for water-power that could attract a financier at that time, and, as Professor Gibson had pointed out, the amount of capital required to utilise water-power was considerable. Now, of course, circumstances had changed. The chemical world had adapted electricity to its uses to a very much larger extent than had obtained hitherto. Aluminium was manufactured at very large profits during the war. Moreover, the price of coal had gone up to a large extent. And there was a new factor altogether which apparently nobody ever thought of in the old days, namely, the idea now current that coal should be conserved. That was the last thing people thought of ten years ago. If one looked at it from the point of view that the water-power was everlasting, while coal would work out in two or three hundred years, that did put a different aspect on the matter. And he hoped that with the assistance of the Committee which the Board of Trade had set up, they would see a great development in the adaptation of water-power for all purposes. No doubt, that being so, there would be in the future a large demand for engineers who had been specially trained to deal with such problems. So far as immediate requirements were concerned, he fancied that the work of the next few years would have to be carried out by the engineers who were already in existence, for this scheme for educating engineers must take time to develop, and if they began with the student at the university it would be a good many years before he had arrived at that period of life when he was likely to be entrusted with large schemes. But the speaker did not think that there was any real difficulty even at the present time. There were plenty of engineers fully experienced in large waterworks schemes in connection with the water supplies to great cities, and in its essence, whether the water was going to be used for power purposes, or for ordinary domestic and municipal purposes, the position from this point of view was very much the same, until, of course, one came to deal with enormous falls such as were found in some parts of the world, though not in this country. But the civil engineering involved was the same whether it was a question of domestic or power purposes. Again, with regard to the electrical side of the matter, electrical distribution and the manufacture of electrical plant for water-power purposes did not differ very much from what was being done at the present moment with steam in the counties of Durham and Northumberland where there was quite long transmission, and also in Cornwall. So that really it came to this, that the only part of a water-power scheme, as to which this country was undoubtedly rather deficient, was the actual designing of water turbines. These had not been made in this country so far to any great size, and he thought he was right in saying that practically all the largest had been imported, chiefly from Switzerland. But he thought there ought to be no difficulty in finding manufacturing firms who were capable of turning out large work in a very short time if there were sufficient demand for it. They could get experience if necessary from abroad. They could import draughtsmen and designers. Hitherto the amount of such machinery which had been required had not made it worth anyone's while to make it. It was simpler to go to Switzerland or Canada and buy the turbines ready made. All this, of course, was only so far as the immediate future was concerned. When the question of what was to be done for the more distant future arose, and they came to deal with the water-power which existed throughout the British Empire, the opportunity for the young men for whose training Professor Gibson had pleaded would arise.

Sir Dugald Clerk, K.B.E., F.R.S., said that the previous week he had appeared before the Society as an advocate of the conservation of the fuel of Britain, and he agreed with the Chairman that evening that, so far as the general public was concerned, little was heard of fuel conservation ten years ago, because coal then was very cheap. Indeed, the coalowners would have been very indignant had there been any talk of fuel conservation. It was their business as business men to raise and sell as much coal as they could. And in one sense it was necessary for the prosperity of the country that industries should be large. The coal industry of Britain was the second largest coal industry in the world, the American being the first, and the German the third. Although the general public had not interested themselves in the past to any great extent in the question of fuel conservation or energy conservation, yet he agreed that it could not be said that the engineers of Britain had not interested themselves in that subject. The struggle of engineers for economy in the use of our natural resources had lasted for more than a hundred years. It began in the eighteenth century, when the Newcomen engine was used, and James Watt was the first coal conserver: not only did he conserve coal, but he increased coal production. The question of coal conservation did not press on the country so heavily so long as the coal was relatively near the surface and could be produced at a cheap rate. So far as business economics were concerned, the question depended on cost, because, of course, no industry could exist unless it made a profit. It might very well be—and this was one of the weak points in all national economy—that there were certain things such as fuel conservation and other matters of conserving

energy which should be looked at from the national interest, apart from the question of cost. He agreed with the Chairman that one was often inclined to say that a business man or an engineer was to blame because an industry was not developed, but the British business man had a very good knack of discovering the thing that was going to pay best. That he succeeded in his operations might be judged from the fact that the average annual income of Britain just before the war was £50·4 per head of the population, and the largest income of any European country. The only country that exceeded Britain in this respect was the United States, and there were special reasons for that. In our great rival, Germany, the income was only £30 per head of population. It was difficult to see how a nation could be run on any other lines than those of business economy. He had no great faith in the socialistic idea of everybody looking after everybody else's business. One did not like to blame engineers or anybody else, but, without imputing blame, there was some truth in the suggestion that it was desirable we should become aware of the enormous potentialities for power, not only in Britain, but in the British Empire; and although his (the speaker's) whole career as a scientific engineer had been devoted to saving heat in the internal-combustion engine, he was so much impressed by this subject that in 1915 he had already prepared a lecture on conserving and utilising the water-power of the world. The great empire problem had not pressed upon us yet, but still when it was considered that the British Empire alone, so far as their researches went, had 50 to 70 million h.p. continuous water-power, it must be realised that that was an enormous asset. To understand what it was one had to remember that in the United Kingdom the census of production, taken in 1907, showed that the total power of all engines in this country was about 10 million h.p. That was a very loose census, and the information gained did not give an idea of the number of hours that an engine had been working at full, half, or quarter power. But assuming that that 10 million h.p. operated at 56 hours a week, a full week, the same sum—10 million h.p.—of continuous water-power would be equivalent to 30 millions of the present steam or other power. Thus the 50 to 70 million h.p. of continuous water-power in the Empire really meant, in terms of steam-power or gas-power, 150 million h.p. (if the 50 were taken) or 210 million (if the 70 were taken). At present the total power of the world was stated by Professor Gibson to be of the order of 100 million. The speaker's own estimate in 1915 was 120 million, but that included shipping, which, he understood, had been left out of account in arriving at Professor Gibson's figure, and represented 24 million. Thus the water-power of the British Empire would almost be equal to the present power of all the world, and that reduced the problem for the future engineer; so long as power and also light could be got in that way, the other problem, of heating, would be capable of being tackled with effect. As to the education of the younger engineers, he quite agreed with Professor Gibson that it was very desirable that they should be educated in hydraulic matters. At the Imperial College of Science and Technology an excellent hydraulic laboratory was built for experimental work, but unfortunately, owing to the war, it had never been used yet for hydraulic purposes. He agreed that there were engineers in plenty able to deal with this subject so far as these islands were concerned, but not enough for the whole British Empire.

Mr. Alfred Dickinson feared he could not agree with Professor Gibson that we were favoured in this country with an abundance of cheap fuel. In discussing the question of cost of power at the Institution of Civil Engineers recently, he pointed out that the cost of power was a relative term, and that what was cheap power for such industries as the manufacture of textiles was dear, and a prohibitive cost to the manufacturer of aluminium, nitrates and such like commodities. To make coal available for the generation of electricity to be used in the manufacture of the commodities just mentioned, coal must not exceed a maximum cost of 5*s.* per ton, and therefore from this point of view there was no such thing as cheap fuel in this country. He saw no very great advantage, excepting in the matter of switchgear, in the utilisation of 52,000 or 100,000 h.p. units. The size of the unit possible was largely governed by conditions. With low heads it might be possible to have such units, but in cases where the head was high, the size of the unit was governed by the pipeline. In one of the two large installations for which he had been personally responsible, namely, the Tata hydro-electric system, the power-house was 1,740 ft. below the forebay. He was most anxious to install the largest units possible, but he found to obtain the necessary factor of safety in the pipelines that his maximum unit was under 14,000 h.p. He mentioned this to show that no generalisation was possible on this question. He was not altogether in agreement with the Professor when he suggested that the available water-power within the Empire was sufficient to perform the major portion of the world's industrial work. The question of the food production of the world had been brought to notice during the war more forcibly than previously, and it was pretty generally believed that the productivity of the cultivatable land was decreasing, and that to maintain its productivity, fertilisers would have to be used to a much larger extent than heretofore. His view was that if the whole of the power mentioned was utilised to manufacture nitrates and other fertilisers, it would not be in excess of the world's needs for those commodities alone. The utilisation of the power resources of the world should receive greater consideration than hitherto. Given any site for water-power development, the first factor to decide before

utilising it was, what in the general interests was the best way to use the power? He suggested that on that basis Loch Leven would never have been utilised for the purpose of manufacturing aluminium. It would have been used for supplying cheap power to Glasgow for general domestic use. Aluminium could be made to greater advantage to the Empire, as a whole, in localities better suited for that purpose. As to utilising the water-powers available in Great Britain and Ireland he did not desire to throw cold water on the possibility of development, but he did suggest that in an old country such as our own the difficulties of adjusting the riparian rights, land purchase and compensation, and such like matters, materially added to the difficulties and the cost to such an extent as to make one believe that unless the law was amended so as to remove these difficulties little progress could be made. The figures and the power available in the various countries given were interesting. He ventured to suggest that at any rate so far as India was concerned, the author did not appreciate the possibilities of water-power development in that Empire. As a British engineer it had been the speaker's privilege to install in that country a hydro-electric installation, which in magnitude could compare favourably with any in the world. Already 60,000 h.p. was being supplied to the mills of Bombay, and at considerably under one halfpenny per h.p. hour. It was the first installation of magnitude which in its first year of working earned and paid a dividend of 8 per cent., and that with a partly developed undertaking. As a result of that development, another scheme was actually under construction for 50,000 h.p., another under contemplation for 150,000 h.p., and a further for 300,000 h.p., making 560,000 h.p. in four schemes; and these four did not by any means exhaust the possibility of water-power development in India. He was somewhat disappointed to find that Professor Gibson, in pointing out the desirability for specially training young engineers in this important section of engineering, had found it necessary to suggest that British engineers had so little experience in hydro-electric developments. That might be so if the Professor referred only to the experience of British engineers within Great Britain and Ireland. If the British engineers as a whole depended upon the work that they could get within Great Britain and Ireland many of them would go to bed hungry. The scope of the British engineer was the British Empire and the world, and from that point of view the British engineer had done almost as much in hydro-electric development as engineers of other nationalities. The speaker was responsible for two large hydro-electric installations, the Tata hydro-electric and the Tasmanian Government hydro-electric undertaking. The Tata hydro-electric presented engineering difficulties not exceeded by any other system ever installed. It was the only hydro-electric installation where the water-supply had been created. On all the other hydro-electric installations there were either existing rivers or lakes. Neither existed in this particular case. The water for the scheme was collected from rain falling in the monsoon in artificial lakes, made by damming three valleys. In the principal dam, one of three, there was more masonry than in the Assuan dam. There was a head of 1,740 ft., which, roughly, gave a pressure of 750 lb. on the low end of the pipeline. There was a transmission line forty-three miles long, working at a pressure of 100,000 volts. The transmission line crossed a tidal creek some miles wide and 40 ft. in depth, and 80 ft. clear head room under wires had to be given at high tide. This was not the time to give the details of the Tasmanian scheme, but it would develop into one of the most important hydro-electric installations in the world. The length of the transmission line was about sixty miles and the pressure 80,000 volts, so, after all, British engineers had had some experience in the installation of hydro-electrics. Whilst the speaker concurred with the Professor as to the desirability of more attention being paid to the possibilities of hydraulic development, he did not attach the same importance to the very special training suggested. So far as the water conservation side of a hydraulic proposition was concerned, he maintained that the ability of the present British engineer was equal to anything obtainable in the world. So far as the pipelines and the turbines were concerned, a good sound mechanical knowledge was the main essential, and so far as the alternators and the transformers and the transmission lines were concerned, the present electrical engineer's knowledge was equal to anything that an installation of this character called for. One of the most important details in connection with high tension transmission line construction was one of pottery ware, and very few engineers had specialised on that detail. The engineers of any other nationality excepting our own were advertising and pushing their special fitness for hydro-electric or any other engineering development. The British press, and the British engineer himself, not infrequently lamented the lack of experience essential to enable him to undertake works of this character. If he had no confidence, how could he expect the financier and the promoters of these various undertakings to employ him? Let us educate ourselves by all means to meet any class of engineering that might come forward, but do not let us in that process advertise the worthiness of engineers of other nationalities, and belittle the knowledge, experience and ability of engineers of our own breeding.

Professor J. C. McLennan, F.R.S., said he had the pleasure of being associated with Professor Gibson during the past two years in connection with the work of collecting data dealing with hydro-electric power within the Empire. He wished to congratulate him on the grasp he possessed of the whole power situation. The problem of the education

of the hydro-electric engineer was presented in Canada for solution some twenty years ago. At that time they had plenty of promising power developments in sight, but very few engineers capable of undertaking the direction of the work of development were available. The University of Toronto, with which he was connected, began at that time to make special provision for the training of hydro-electric engineers, and in the interval which had elapsed many engineers of high capability and attainment had been graduated, and were now employed on Canadian works and in electric distribution systems in that country. The University of Toronto was the largest university in the Empire, and with its magnificent hydraulic and electrical laboratories it should not be overlooked by anyone desiring to study the latest methods in hydro-electric development. He believed that the superintendent of the Hydro-Electric Department at Ottawa was a graduate of Toronto. So was Mr. Gaby, the engineer-in-chief of the Hydro-electric Power Commission of Ontario. This Commission also employed some three hundred engineers mostly trained in Toronto. He mentioned this to show how the people of Ontario appreciated the importance of hydro-electric engineering, and he ventured to say that if engineers were trained in Great Britain and looked for employment in Canada it might be difficult for them to get it there. The amount of hydro-electric power capable of development in Great Britain was limited, and British trained engineers would probably have to seek employment outside the country. The Empire, however, was large, and, apart from Canada, there would be many openings in India and in the other Dominions and dependencies. The field for development extended moreover to foreign countries. What he should like to see emphasised in Great Britain was the higher training of chemical engineers. In the utilisation of large blocks of hydro-electric power in electro-chemical processes there were immense financial and scientific possibilities. In the war British scientists had shown what magnificent work they could do in this field. Exploitation should be encouraged in every possible way in this direction, for along that path lay the greatest rewards for industry.

Major Philip Dawson said that the paper deserved careful consideration in what it had to say about the education of the future generation. In the past he thought Great Britain had held its own, but it was only by realising the difficulties ahead that it would continue to hold its own in the future. He agreed with the remarks of the Chairman; at the same time, having a good deal of personal acquaintance with conditions in other parts of the world, notably in the United States and in Europe, he could not help feeling that any engineer would find it very difficult to get men already trained whom he could send out to investigate new properties with a view to the generation of hydro-electric power. That, however, did not seem to be the case in Canada. When the falls of Niagara were first harnessed, they had to go abroad for engineers, but now Canada, as they had heard, had sufficient engineers of her own. As a member of the Water-power Resources Committee of the Board of Trade, he had realised that there was a much larger amount of water-power available in this country than was thought at one time, and owing to the war there was a possibility that that would be utilised. This would employ British engineers, and, he hoped, British engineers only. He had not heard much in that discussion about Africa and its enormous possibilities. A large portion of that continent was now under the Imperial flag.

Mr. Alfred Dickinson pointed out as a matter of historical fact that the first development of Niagara was by Lord Kelvin and Professor Forbes.

Professor D. S. Capper said that it seemed to him that the line which had been suggested by the reader of the paper was really the sound one. There were fairly thorough general training courses in most institutions, but the side on which hitherto they had been least developed in this country was the application of the general training to special problems. Professor McLennan had stated what had been done in Toronto, and that was the line upon which they wanted to lay stress at the present time. At the root of the problem was the question of financial help. Most of the colleges and universities would be only too thankful to develop on some special line, but the great point was that in Canada and the United States there were people who had made great fortunes in various directions, and who were prepared to put money down to help the institutions to do the work. This training did want money. It was a mistake to lay down installations at places where there could be no direct access to and contact with commercially run plants. To attempt hydro-electric engineering training in London, for example, except on the preparatory side of it, would be a mistake. Post-graduate education must be in close contact with actual commercial developments.

The Hon. Sir John McCall (Agent-General for Tasmania) said that he represented a country where one of these great works had been carried out. They were carrying it out under a report made by Mr. Dickinson, and the engineer-in-chief was also a British engineer. It seemed to be clear, from the remarks of a preceding speaker, that the educational difficulty might be got over if, instead of spending a great deal of money, they sent over a dozen or twenty students every year to Toronto. Specialisation in the application of electricity for chemical processes was very necessary. In the construction works with which he was associated there had been no difficulty in getting engineers within the

Empire, but there had been difficulty in getting hold of men to establish industries. For the carbide work they had to get a man from Sweden; and the original man for the zinc work, he thought, came from America. Certainly the Empire ought to be able to supply its own technical men.

Mr. H. E. M. Kensit said he was much impressed by the value and importance of Professor Gibson's suggestion as to the initiation of special training in Great Britain for hydro-electric engineers. He was well aware that we already had amongst us a few highly qualified men, but it was evident that a much greater number would be required. He desired to indicate how great the field for such engineers would probably be. As Professor Gibson had shown, there were at least 50 to 70 million h.p. available in the Empire. Both before and during the war our friends and our enemies had been active in the development of water-power resources. Europe, taken as a whole, had now developed about 18 per cent. of its available power, the United States 20 per cent. and Japan, a small country but an active competitor, constructed 16 per cent. of her entire power capacity in 1917 alone, and now had over 1,000,000 h.p. of hydro-electric power developed. Against the 18 per cent. of Europe, and 20 per cent. of the United States, the British Empire had only 5 per cent. developed, and of this 70 per cent. was in Canada. Without Canada the British Empire had less than 2 per cent. of this great resource developed. It might therefore be said that practically the whole of the work had yet to be done, and it appeared very clear to his mind that commercial competition would compel the development of a large amount of this power in the near future, and that if British trained engineers were not available in sufficient number much of the engineering and therefore of the orders for plant and material would go abroad. Being concerned himself with hydro-electric work he would like to emphasise the point that a fully qualified hydro-electric engineer should possess qualifications beyond those ordinarily implied by the term hydraulic engineer, since many special problems were involved. It was, for instance, a comparatively simple matter to develop the most obvious site on a river; but it was another matter to design a comprehensive scheme to secure the maximum advantageous use of the whole river in such a way that each development, when made as circumstances warranted, would be a link in the complete scheme of utilisation. To do this to the greatest advantage required the development by study and experience of a special faculty for visualising and comprehending the maximum power possibilities of a river, or power reach of a river, as a whole, and making a complete study from that point of view. Developments were constantly increasing in size, and future plants would have to be constructed in many parts of the Empire to utilise 1,000,000 h.p. or more in a single development, involving units up to 100,000 h.p. each. Many highly technical problems would also be involved in relation to ice troubles, floods, storage, etc. Professor Gibson had already pointed out the need for thorough electrical training to deal with problems of generation and transmission. The speaker would like to emphasise that one of the most vital requirements for a hydro-electric engineer was special training in the financial and in the commercial sides of engineering. Hydraulic engineering, for waterworks supply, navigation of rivers, docks and harbours, etc., was usually carried out to meet existing requirements, as also was steam engineering; but hydro-electric work usually involved proof of its commercial feasibility before any development could be secured. Special skill in studying and presenting the financial and commercial prospects was, therefore, unusually essential. In the same connection there was the necessity for an expert analysis of the present and future power market, a matter requiring considerable study and experience to present in a reliable and far-seeing manner for the whole of the possible area of transmission. It would be seen that the hydro-electric engineer of the future would have to deal with very extensive and comprehensive river studies in many parts of the Empire, with developments of great size, with great transmission schemes, and, primary and most vital of all, the expert analysing and proper presentation of the commercial feasibility of each scheme as projected. It was therefore very evident that training, specially designed to develop the capacity for work of such great scope and importance, needed to be initiated in this country at once, if much of the engineering and manufacturing was not to pass to other countries.

Mr. E. A. Atkins thought that the matter ought to be looked at from the point of view of the good of the nation. At present water-power was largely running to waste. Was that to continue because it did not come within the purview of the company promoter? Could not some scheme be devised whereby the various waterfalls, etc., could be dealt with nationally?

Professor Gibson, in reply, said that he was sorry he did not find it possible to be in such an optimistic frame of mind as the majority of the early speakers. One had to remember that the enormous developments in Canada, New Zealand and India during the last ten years had only been carried through to a comparatively small extent by British engineers. In India at least 50 per cent. of the work had been done by foreigners. In the Tata scheme itself the technical experts for both the hydraulic and the electrical sections of the work were not British. In New Zealand, until recently, very little of the hydraulic machinery employed had been made in this country, and the same applied to Tasmania. It might not have been worth the while of British

engineers in the past to go into this question of hydro-electric development; they were able to make money more easily. But the point was that hydro-electric development was going to be enormously more important in the future. A great proportion of this 50 to 70 million h.p. would ultimately be developed, and the question was, to whom was this development to be entrusted? Was it going to be left to those interests which had been responsible for the great majority of the developed water-power in the world, or was it to be developed from this country? They had heard that there were any number of British engineers available to do the work, but he was talking two weeks ago with one of the leading hydraulic engineers in this country, whose firm had been responsible for some of the largest schemes, and he (the speaker) asked him how, if he wanted to develop a scheme, he would provide the engineers. The reply was, "I have a few men whom I have trained for myself; one or two are from this country, the others from New Zealand, but outside these I should have to go to Sweden or Canada." This authority added that if half a dozen hydro-electric schemes were to be developed at once in this country, it would not be possible to get British firms with British engineers to tackle the whole of the work simultaneously. Personally, the speaker was afraid that this was true. The point Mr. Atkins had raised with regard to water powers being developed in this country, whether they were commercially paying propositions or not, was one that would have to be left for the moment. Ultimately, as coal resources were depleted, the demand for these powers must become greater and greater, and all that could be commercially developed would be developed ultimately.

A vote of thanks was accorded to Professor Gibson for his interesting paper.

Mr. H. M. Surtees Tuckwell, of Messrs. Tata, Ltd., writes: I should like to record my appreciation of the question raised by Professor Gibson, with which I am in entire sympathy. As my duties here cover the purchase of materials for hydro-electric power-stations, I may claim to some little knowledge of the resources in this country of the various materials required for the equipment of hydro-electric stations. I regret to say that my investigations have shown that our manufacturers of Great Britain are certainly behind those of America and Germany in the manufacture of some of the most important items required in this form of engineering. I believe that no firm in this country has yet made a pipeline comparable with the largest of those constructed by Germany and America, nor have they produced units of the sizes now being manufactured in the United States, and the supply of insulators, capable of withstanding the extraordinarily variable climatic conditions, such as are met with in India and in some parts of America, have up to the present compared somewhat unfavourably with similar materials produced in the United States. The magnificent efforts of engineers and manufacturers throughout the war have proved indubitably that British engineers and manufacturers are capable of attaining the highest standard, and meeting almost any demand made upon them, and it is our geographical position and the lack of demand for these materials in the United Kingdom that have led to these important manufactures being somewhat neglected. I am cordially in sympathy with the proposal which Professor Gibson makes, "that a corporation be formed, augmented and strengthened by Canadian experts," and believe that a close co-operation between British and Canadian manufacturing firms may result in placing us in the first rank as manufacturers of entire hydro-electric equipment, and in the possession of hydro-electric engineers equal to any in the world. India, with whose natural resources and requirements I am more familiar, is likely to develop very rapidly in the near future, and many hydro-electric installations are being and will be projected, and I believe it to be to the highest interest of the Empire that we should be in a position to secure both the engineering and manufacturing business, and not have to stand by and see them pass to other countries because of the lack of experience and resource within these islands.

ART AND INDUSTRY.

No. 17 of the series of pamphlets dealing with reconstruction problems is entitled "Art and Industry,"* and will be welcomed by all who have the future of British industries at heart. It is devoted to a discussion of the various aspects of a question in which the producers, the distributors, and the purchasers are the three dominant factors, and emphasises the importance of improved educational facilities for all three if quality in design, material, and workmanship is to enable British goods to take a leading place in the markets of the world. The arguments for securing the re-union of craft and industry—that "unhappy couple," as the pamphlet calls them, whom modern industrial development has all but divorced—are cogently and suggestively set forth; and in this connection the place of the art schools ("which should be the educational backbone of industry") in the education of producers and distributors is carefully considered. "Schools of Art should be grouped in areas and organised in a well-ordered scheme, culminating in central colleges. One of the most important functions of such colleges would be research into the possibilities of artistic processes and opportunities for their application in production, especially as regards manufactures and handicrafts carried on in the areas. The local industry should be the *focus and source* of the work of the school of art. To attain this object the educationist, the employer, and the employed must have confidence in one another and work together."

* Published by H.M. Stationery Office. 2*d.* net.

The education of the distributor—which has been too long neglected—is carefully discussed. The buyer has almost a tyrant's power to make, or at all events to mar, the sale of any article in which he deals, for if he refuses to look at a new design, even though it were the best in the world, the public would never see it. In a smaller way the shop salesman is an arbiter of fashion. Yet what has been done to cultivate his knowledge or taste? It is only within the last three years that the L.C.C. Central School of Arts and Crafts has taken up the matter and instituted a course for young assistants from wholesale and retail houses who attend on two mornings a week during business hours. It will be interesting to watch the results of this experiment, and to see whether by the intelligent co-operation of designers, craftsmen, manufacturers and distributors the taste of the great purchasing public can be stimulated in the right direction. In the case of the younger apprentices to the industrial world, perhaps most is to be expected from the machinery provided by the New Education Act, under which the present haphazard instruction of voluntary evening classes can be replaced by a disciplined training given during the day in the employer's time.

It may not be out of place in this *Journal* to recall the fact that some of the problems discussed in this pamphlet were the subject of anxious consideration by the founders of the Society of Arts. At the very first meeting of the Society, which was held at Rawthmell's Coffee House in 1754, it was decided "to bestow premiums on a certain number of boys and girls under the age of sixteen who shall produce the best piece of drawing, and show themselves most capable when properly examined . . . it being the opinion of all present that the art of drawing is absolutely necessary in many employments, trades, and manufactures." These premiums continued to be offered till 1849, and they were awarded to a large number of candidates who subsequently attained great distinction in the worlds of art and industry.

SHELL FISHERIES OF THE ANGLO-EGYPTIAN SUDAN.

The shells exported from Egypt are not a Mediterranean product, but come from the Red Sea. They are known simply under the generic name of "mother-of-pearl," and are found along the African Red Sea coast from Suakin to Djibuti, as well as near the Dahlac and Massowah Islands. Suakin and Port Sudan are the Sudanese points of collection and export. Other ports where shells are collected are Umbig, Kosseir, Wegh, Hinfida, El Subaya, Facz Gabal, and Hassany. So far as can be ascertained the industry is not organised, and is carried on along most primitive lines. The shells are obtained in comparatively shallow water through diving by natives, without apparatus. A rough kind of helmet is occasionally found in use.

From a report by the United States Consul at Alexandria it appears that the shells of commercial value found in the Red Sea include the following: (1) The ordinary mother-of-pearl shell (Meleagrina Margaritifera), (2) the shell of a fish with six fin-like projections (Pteroceras lambis), (3) the top shell (Trochus), (4) a large kind of clam shell (Tridacna gigas), and (5) many species of cowrie or porcelain shells (Cypræa div. op.).

According to official statistics, the quantities and values of the mother-of-pearl shells exported from the Red Sea ports of the Anglo-Egyptian Sudan during the years 1914–16 were:—

Exported to	1914.	1915.	1916.
Egypt—			
Pounds . .	2,418	—	55,078
Value £E . .	82	—	1,874
Eritrea—			
Pounds . .	5,734	—	158,038
Value £E . .	196	—	5,079
Great Britain—			
Pounds . .	57,768	1,984	—
Value £E . .	1,862	68	—
India and Aden—			
Pounds . .	4,806	103,062	113,990
Value £E . .	164	3,512	51,705
Total Pounds . .	70,726	105,046	327,106
Value £E . .	2,304	3,580	148,373

[The Egyptian pound is equivalent to £1 0*s.* 6¼*d.*]

SALT INDUSTRY OF SOUTH INDIA.

Salt production employs a large number of people in the Madras Presidency. It is a State monopoly, and the salt is obtained chiefly by the evaporation of salt water. Some pans are worked by the Government, but the majority are in the hands of lessees, whose output is checked by Government inspectors.

The annual report of the Department of Salt Revenue, Madras Presidency, states that the output of salt in 1916–17 was 481,086 tons. Production was carried on at forty-eight centres, divided nominally into sixty-five establishments, all on the east coast of the Presidency. These sixty-five factories are grouped into four classes, as follows:—

(*a*) Those worked directly by the Government as demonstration factories, viz., the experimental pans at Pakala, Krishnapatnam, Vayahur (including the modern Saltern), Sevandakulam, Levingepuram, and Arumuganeri, comprising in all about 234 acres.

(*b*) Seventeen monopoly factories, comprising 5,895 acres, held by licencees who are bound to sell their salt to the Government.

(*c*) Eight whole factories, two extensions of monopoly factories, and four extensions of excise factories, comprising in all 1,415 acres, held by modified excise licencees, who are bound to sell their produce to the Government if a demand is made, generally before the commencement of production, but who are otherwise free to sell as they please. Six of these factories were held on leases that contained terms requiring the conduct of production under improved processes and the

destruction of salt which did not attain a fixed standard of purity.

(*d*) Thirty-nine factories, comprising 6,209 acres, held by excise licensees, who produce for sale to the public subject to payment of duty.

The demonstration factories produced 5,307 tons; monopoly factories, 176,642 tons; modified excise factories, 40,885 tons; and excise factories, 257,444 tons.

Experiments in the production of light and pure salt, and of pure, white, and heavy salt, were continued at the demonstration factories, the conclusion being that the two essentials to production of light salt are a soft surface to a bed free from sand and the elimination of the flake salt which forms on the surface of the brine. For purity, washing in brine of a density of about 25 degrees Beaumé was found to be the most important factor. The ordinary system was continued at the remaining three classes of factories with a few modifications, among which were: Scrapings were generally conducted in the cool hours of the morning or evening; salt scraped was washed in all the factories of the Tinnevelly subdivision and in a portion of the Chinnagamjan factory, but when washing was enforced the rules relating to the density at which salt should be scraped were relaxed; the concession of drying on the ridges was allowed in the Manginapudi and Markkanam factories, in all the factories of the Ennore Circle, and in those of the Negapatam subdivision except Negapatam.

Measures taken for increasing the production of salt consisted in extending the season so far as possible, increasing the producing area in existing factories, and the opening of new factories and extensions. It is believed that these measures will necessitate an increased supply of the shallow salt pans usually imported from abroad for this industry.

The number of factories engaged in the manufacture of crude saltpetre was 1,037, and the number of refineries 25, these latter nearly all in the Trichinopoly subdivision. As compared with an output of 242 tons of refined saltpetre in the previous year, 339 tons of refined saltpetre were produced in 1916–17, the increase being probably due to the greater demand for the local article consequent on the war.

A small beginning was made during the year in the manipulation of bitterns for the production of Epsom salts.

According to a report by the United States Consul at Madras, there are four great sources of supply of salt in India—rock salt from the Salt Range and Kohat Mines in the Punjab; brine salt from the Sambhar Lake in Rajputana; salt brine condensed on the borders of the lesser Rann of Cutch; and sea-salt factories in Bombay, Madras, and at the mouth of the Indus. In Bengal, the damp climate, together with the large volume of fresh water from the Ganges and the Brahmaputra into the Bay of Bengal, renders the production of sea-salt difficult, and the bulk of the supply, both for Bengal and Burma, is imported.

The imports of salt into India from abroad in 1916–17 were 445,000 tons, valued at £1,274,000, the lowest recorded during the last twelve years. Salt in normal times was carried to India almost from necessity rather than from choice, standing as it does between ballast, for which a ship has to pay, and the least remunerative cargo. The production of Indian salt in 1916 was 1,359,000 tons, a decrease of nearly 2½ per cent. from the output of the previous year.

GENERAL NOTES.

THE MERCHANTS' ASSOCIATION OF NEW YORK.—This association, which has a membership of over 5,700 of the most prominent New York merchants and manufacturers of all classes of goods, employs a large permanent staff for the purpose of fostering the foreign trade of the United States and assisting foreign firms to get into touch with American houses interested in their line of commodities. They furnish lists of firms in the United States to responsible inquirers who wish to obtain information regarding American trade. No charge is made for these services. Communications should be addressed to the Secretary of the Association, 233 Broadway, Woolworth Buildings, New York.

PROPOSED COMMUNITY SETTLEMENT IN BRITISH COLUMBIA.—Three hundred Canadian officers and men on the voyage to the Dominion agreed on a cut-and-dried plan of settlement on a co-operative basis for submission to the Government. They have asked the British Columbia Government to allot them a portion of the well-known Southern Okanagan tract. The Vancouver correspondent of the *Times* says that they have not met with as much encouragement from official sources as might have been expected, but there is still some chance that the experiment will be tried. The plan is to utilise the settlers for providing needed irrigation works. The Dominion Government is asked to advance to a committee representing the settlement a sum not exceeding £1,000 per settler. The lands would be held individually, and the buying of machinery, lumber, seed, etc., be done collectively.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

APRIL 30.—SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. "Glass, and Some of its Problems." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 7. — JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

MAY 14.—H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom." MAJOR-GENERAL SIR PHILIP NASH, K.C.M.G., C.B., will preside.

MAY 21.—SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Japanese Design."

MAY 28.—HARRY J. POWELL, "Glass-making before and during the War."

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m. :—

MAY 15.—PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies in India, with special reference to Indigo." SIR WILLIAM DUKE, G.C.I.E., K.C.S.I., will preside.

Dates to be hereafter announced :—

BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aerial Transport as affecting India."

SANDFORD J. KILBY, "Indian Salt Manufacture."

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 28...London Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Mrs. W. E. V. Crompton, "The Ideal Street—a Neglected Aspect of Town Design."

East India Association, 3, Victoria-street, S.W., 3.30 p.m. Mr. K. Gauba, "Indian Literature: Past, Present, and Future."

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m. Mr. J. H. Sabin, "Notes on the Report of the Agricultural Policy Sub-Committee of the Reconstruction Committee."

Geographical Society, Burlington-gardens, W., 8 p.m. Mr. H. F. D. Philby, "Southern Nejd."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Mr. P. H. McCormack, "Group Insurance."

TUESDAY, APRIL 29...Post Office Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m.

Engineers and Shipbuilders in Scotland, Institution of, Royal Technical College, Glasgow, 7.30 p.m. Dr. A. McCanco, "Stress Lines in Steel after Permanent Deformation."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Wales and Ireland." (Lecture I.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Annual General Meeting.

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. G. Avenell, "West of England Notes."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Dr. W. T. Calman, "Exhibition of Marine Boring Animals." 2. Mr. N. Tayler, "A Unique Case of Asymmetrical Duplicity in the Chick." 3. Mr. G. Jennison, "A Chimpanzee in the Open Air in England."

Horticultural Society, Drill Hall, Buckingham-gate, S.W., 3 p.m. Dr. F. Keeble, "Horticultural Education and Research."

Faraday Society and the Röntgen Society (Joint Meeting), at the Royal Society, Burlington House, W., 5 p.m. and 8.30 p.m. 1. Professor W. H. Bragg, "Radiometallography." 2. Professor A. W. Porter, (a) "Investigation of Metals by means of X-rays." By Messrs. F. Janus and M. Reppchen; (b) "The Principles governing the Penetration of Metals by X-rays." By Dr. G. Respondek. 3. Messrs. H. Pilon and G. Pearce, "Apparatus used for Radiometallography." 4. Captain R. Knox and Major G. W. C. Kaye, "The Examination of Timber by X-rays." 5. Sir R. Hadfield and Messrs. S. A. Main and J. Brooksbank, (a) "Testing the Absorption power of different Steels under the X-rays"; (b) "X-ray Examination as applied to the Metallurgy of Steel"; (c) "Radiographic Examination of Carbon Electrodes used in Electric Steel Making Furnaces"; (d) "A Method of Testing an X-ray Tube for Definition." 6. Lieut.-Col. C. F. Jenkin, "The Detection of Hair Cracks in Steel by means of X-rays." 7. Mr. F. F. Renwick, "The Behaviour of Photographic Plates to X-rays Considered in Relation to the Radiography of Metals." 8. Dr. R. E. Slade, "Contrasts in X-ray Photographs." 9. M. E. Schneider, "Radiometallography."

WEDNESDAY, APRIL 30...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. "Trueman Wood" Lecture. Sir H. Jackson, "Glass and Some of its Problems."

Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Major H. E. Wimperis, "Aerial Navigation."

THURSDAY, MAY 1...Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. J. Small, "The Pappus in the Compositæ." 2. Mr. M. Drummond, "Notes on the Botany of the Palestine Campaign. I.—The Flora of a small area in Palestine." 3. Mr. H. N. Dixon, "Mosses from Deception Island."

Chemical Society, Burlington House, W., 8 p.m. Professor J. H. Jeans, "The Quantum Theory and New Theories of Atomic Structure."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. H. S. Hele-Shaw, "Clutches." (Lecture I.) 5 p.m. Annual Meeting.

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Dr. C. Chree, "Magnetic Storms."

FRIDAY, MAY 2...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor J. W. Nicholson, "Energy Distribution in Spectra."

Engineers, Junior Institution of, 39, Victoria-street, S.W., 7.30 p.m. Major H. P. Philpot, "Notched Bar Tests."

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Dr. W. H. Hatfield, "The Mechanical Properties of Steel, with some consideration of the question of Brittleness."

SATURDAY, MAY 3...Royal Institution, Albemarle-street, W., 3 p.m. Professor H. S. Foxwell, "Chapters in the Psychology of Industry." (Lecture I.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—April 25, 1919.

No. 3467. MAY 2, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,467. VOL. LXVII.

FRIDAY, MAY 2, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

Wednesday, May 7th, at 4.30 p.m. (Ordinary Meeting.) John Somerville Highfield, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." Alan A. Campbeel Swinton, F.R.S., Chairman of the Council, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 30th, 1919; Alan A. Campbell Swinton, F.R.S., Chairman of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Blight, Francis James, F.R.S.E., Wembley, Middlesex.
Boase, William Norman, C.B.E., St. Andrews, Fife.
Bode, Sorabjee Hormusjee, Bombay, India.
Brocklebank, Ernest, J.P., Caton, Lancaster.
De Majumdar, Indu Bhushan, Cooch Behar, Bengal.
Dyson, Rear-Admiral Charles Wilson, U.S.N., Washington, D.C., U.S.A.
Ebrahim, Ahmed Currimbhoy, Bombay, India.
Howeson, A. C. E., Calcutta, India.
King, Henry George, Lincoln.
MacGuckin, Charles John Graham, C.B.E., Assoc. M.Inst.C.E., M.I.Mech.E., Newcastle-on-Tyne.
MacLeod, James MacIver, C.M.G., Valparaiso, Chile.
Mason, William, London.
Needham, Lieut.-Colonel Joseph G., D.S.O., Didsbury, Manchester.
Paton, George William, London.
Pickthall, Frank John, Buenos Aires, Argentina.
Ritchie, Frederick George, Singapore, Straits Settlements.
Royle, Harry, Cabinda, Portuguese Congo.
Ryan, Joseph S., Montevideo, Uruguay.
Sadler, Thomas J., London.
Schneider, Charles Eugène, Paris.
Stancourt, John Augustus Frederick, London.
Suttie, P. E., Calcutta, India.
Wyer, Raymond, Worcester, Mass., U.S.A.

The following candidates were balloted for and duly elected Fellows of the Society:—

Baria, Raja of (Captain His Highness Maharaol Shree Ranjitsinhji), Devgad Baria, India.
Bedford, Jesse, Wh.Ex., A.M.I.Mech.E., A.M.I.A.E., Sparkbrook, Birmingham.
Fawcett, James W., Sheffield.
Garnett, Cecil Stevenson, Matlock.
Jackson, Captain Edward Almond, R.A.F., Doncaster.
Judge, Lieut. Arthur W., R.A.F., A.R.C.Sc., Wh.Sc., A.M.I.A.E., Butley, Suffolk.
Rosling, Sir Edward, London.
Smith, T. Graves, M.I.Mech.E., Stonehouse, Gloucester.
Stone, Leslie Norman Waldegrave, Woolwich.

The "Trueman Wood" Lecture on "Glass, and Some of its Problems," was delivered by Sir Herbert Jackson, K.B.E., F.R.S.

The lecture will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

SIXTEENTH ORDINARY MEETING.

Wednesday, April 2nd, 1919; Sir Frank Warner, K.B.E., in the chair.

The paper read was—

FLAX.

Cultivation, Preparation, Spinning, Weaving.

By W. Norman Boase, C.B.E.,
Chairman of the Scottish Flax Spinners' and Manufacturers' Association.

The origin of the flax plant (*Linum usitatissimum*) is doubtful, and like most plants which have been long under cultivation it possesses numerous varieties. It is an annual, with an

erect stalk rising to a height of from 20 to 40 in. and branching at the top, each branch ending in a regular and symmetrical flower, usually of a bright blue colour, though Friesland flax and some Dutch flaxes have a white flower. The fruit, or boll as it is called, is round, containing five cells each, subdivided into two, thus forming ten divisions, each of which contains a single seed. The seeds are oval in section, and are heavy, smooth and glossy, and greenish-brown in colour.

The earliest cultivated flax was *Linum augustifolium*, a smaller plant with fewer and narrower leaves than the *Linum usitatissimum*, and usually perennial. This is known to have been cultivated by the inhabitants of the Swiss lake dwellings, and grows wild in Africa and Western Asia, and in Southern and Western Europe, including England and the South of Scotland. The annual flax (*Linum usitatissimum*) has been cultivated for probably five thousand years in Mesopotamia, Assyria and Egypt, and grows wild in the districts included between the Persian Gulf, the Caspian Sea, and the Black Sea. This annual flax was probably introduced into Northern Europe by the Finns, afterwards into Western Europe by the Western Aryans, and possibly here and there by the Phœnicians, lastly into Hindustan by the Eastern Aryans after their separation from the European Aryans. The cultivation and preparation of flax are among the most ancient of all textile industries, and there are preserved to the present day distinct traces of their existence during the Stone Age.

Flax was most extensively used and variously applied in the lake dwellings. Unfortunately, although rough clean flax ready for use has been found in the lake dwellings, we can form no idea of how it was prepared or cultivated; it is known, however, that it was used for making lines and nets for fishing and catching wild animals; cords for carrying earthenware vessels and other heavy objects—in fact, one can hardly imagine how navigation could have been carried on, or the lake dwellings themselves made, without cords and ropes; and the erection of the dolmens and menhirs—possibly even of the Pyramids themselves—would have been almost impracticable without the use of strong flaxen ropes.

Flax fibre, which is probably the strongest and most durable of all vegetable fibres, certainly occupied a most important place in Egypt, and its uses are frequently referred to in the Bible.

Linen was always chosen where cleanliness and purity were required, and was invariably worn by the priests. The high priest's ephod and mitre, as well as the turbans and robes of the priests, were made of fine linen, and when these garments became worn out they were unravelled to make wicks for the lamps at the Feast of Tabernacles.

It is interesting to recall that one of the plagues of Egypt was the destruction of the flax crop by hail, and the recent taking of Jericho reminds us of how Rahab hid Joshua's spies with the stalks of flax which she laid in order upon the roof.

Research has brought to light also several curious grottoes and tombs in Upper Egypt, covered with paintings as distinct and brilliant as when first executed, illustrating with remarkable fidelity and minuteness all the various flax processes, pulling, steeping, scutching, spinning and weaving.

Flax was probably first brought to this country by the Romans, who had a factory at Winchester; but although it is known that linen fabrics were fairly common in England, there is little reference to them to be found till the end of the twelfth century, when evidently the crop had attained considerable dimensions, as it was included among the titheable articles. In the middle of the sixteenth century, owing to imports (including linen) having increased very much, and many people being idle in consequence, Henry VIII. passed an Act compelling farmers to grow flax to the extent of one rood for every sixty acres cultivated. Thirty years later this Act was made more stringent, and all farmers not growing one acre of flax out of every sixty acres cultivated, were fined £5.

Further methods of increasing the area devoted to flax were adopted towards the end of the seventeenth and beginning of the eighteenth century, when the amount of tithe was reduced, a bounty was offered on all exported British-made sail cloth, and laws were passed compelling people to wear linen hat bands and scarves at funerals, and to bury their dead wrapped in plain linen. It is not easy to discover what was done in Scotland regarding growing flax in these early times; but one Roman historian refers vaguely to the Caledonians using some linen apparel. He states they lived in a state approaching nudity, but does not indicate whether this was from choice or necessity. Knowing our climate we must form our own conclusions.

In very early times in our Highlands women went with their heads bare until after marriage,

when they wore a linen mutch, and early in the fourteenth century linen was assuredly in considerable use; indeed, it is given some credit for helping to win the Battle of Bannockburn, as history relates that "the women and camp followers put on shirts, smocks and other white linens and bound flaxen towels and napkins on staves, and, making a great show, came down the hill in face of the enemy with much noise and clamour, whereat the English, supposing it to be a reinforcement, turned and fled."

In 1711 a Board of Trustees was established in Ireland, and in 1727 a similar Board was appointed in Scotland for administering annual sums for the encouragement of manufacturers, and premiums were given for weaving and spinning, as well as for growing flax. These Boards did much good, certainly to begin with, in fostering the linen industry.

The flax industry was at this time on what might be called a domestic scale. Most farmers and landowners grew flax or lint, as it was often called, in small patches, and it was prepared, spun, and woven on their own premises, or, after being spun, was sent to the village webster to be woven.

This practice kept the industry away from any motive to apply labour-saving devices, and it was only by slow degrees, when stimulated by the Board of Trustees and others, that machinery was invented and mills were established.

Towards the end of the eighteenth century many proprietors introduced a clause in the lease of farms restricting the amount of flax to be sown.

They held that flax was a dirty and exhausting crop; and as probably the flax was not sown on clean land nor in the best rotation, and very likely the seed itself was not properly cleaned, there may have been something in their contention.

The maximum acreage under flax in England was in 1870, when 24,000 acres were cultivated. Seven years later this fell to 7,000 acres, and thereafter decreased steadily and gradually. The average for 1881 to 1890 was 2,900 acres; for 1891 to 1900, 1,300 acres; for 1901 to 1910, 480 acres; and prior to war the acreage was only between 200 and 300.

In Ireland the first record is 58,000 acres in 1847, rising to 174,000 in 1853, and falling to 97,000 in 1856. The maximum was reached in 1864, when 302,000 acres were sown, but this was immediately following the cotton famine, and the acreage dropped the following year to 251,000 and to 122,000 in 1872. Between this time and 1890 it fluctuated considerably, the highest being 157,000 acres in 1880, and the lowest 89,000 in 1884. Thereafter it declined with fluctuations, the average between 1896 and 1910 being 48,000, the lowest being in 1898, when only 34,500 acres were sown. The last five years' acreages have been—

1914	49,253
1915	53,143
1916	91,454
1917	107,566
1918	143,355

The reason for the violent character of the fluctuations in pre-war days in Ireland is that flax is not an essential part of the rotation of crops. Temporary grass, grain, and green crops in systematic rotation are essential to husbandry, as they are necessary either for the cleaning and amelioration of the soil or for the maintenance of stock kept upon it. Flax is not required for the one or the other, and the farmer grows it very often as a stolen crop between two of the staple crops when he happens to have a piece of ground specially suitable for its growth or when prospects of a good price for fibre are attractive.

In Scotland the area under flax reached its maximum in 1854, when 6,670 acres were sown. Three years later the figures had fallen to 1,534; thereafter it dwindled and died down almost entirely till 1885, when an endeavour was made to resuscitate the sowing in Fife; scutching plant of modern type was put down and warm-water retting introduced. In 1887 about 900 acres were under cultivation, but success did not attend the endeavour, and the crop soon went practically entirely out of cultivation.

In examining those figures it is well to remember that the term flax is used to denote the crop grown for linseed as well as the crop grown for fibre, and the acreages mentioned include for England and Scotland both these crops, whereas for Ireland, where flax for linseed is not grown, the figures are the flax fibre crop.

Briefly, the reasons for the decline of flax cultivation for fibre were the introduction of cotton and the successful spinning of that fibre, the importation of large quantities of Russian flax after the Treaty of Paris in 1856 and peace with Russia had been declared, the centralisation of the linen trade in a few districts only, which deprived farmers of their local markets, and the fact that whenever prices for grain were remunerative farmers were glad

to be relieved of the troublesome after processes of flax preparation. The production of flax has been very considerably reduced during the last thirty years in all European countries except Russia.

		Acres.		Acres.
Belgium . . .	1893	91,993;	1909	39,288
France . . .	1894	81,965;	1909	50,511
Holland . . .	1890	40,780;	1913	36,185
Rumania . . .	1902	102,117;	1910	33,103
Austria-Hungary.	1898	197,373;	1913	89,913
Germany . . .	1880	319,396;	1900	83,147

It has been impossible to obtain figures for corresponding years for the various countries, but generally it may be accepted that in the above six countries the total acreage under flax was, prior to war, probably less than half what it was thirty years previously.

Russia is by far the largest flax-producing country in the world, and, unlike other European countries, the cultivation of flax did not decline in pre-war years. On the contrary, it tended to increase, but no very reliable statistics can be obtained because a large quantity of flax is grown by the peasants for their own use and in very small quantities of an acre or less. Probably a conservative estimate is that prior to the war Russia had under flax cultivation 3,800,000 acres, producing 525,000 tons of flax fibre, of which she exported to—

United Kingdom	86,400 tons.
Belgium	60,500 ,,
France	34,700 ,,
Germany	60,400 ,,
Austria-Hungary	22,000 ,,
Total . .	264,000

These export figures are for ten years pre-war average. In 1913 Great Britain and Ireland imported 102,443 tons of flax fibre made up as follows—

Russia	81,567 tons.
Belgium	18,006 ,,
France	278 ,,
Holland	1,668 ,,
Germany.	519 ,,
Other countries.	405 ,,

Ireland in the same year produced 12,652 tons, and it may therefore be assumed that the United Kingdom used from 100,000 to 110,000 tons of flax fibre, of which between 80 and 90 per cent. was imported.

Some years before the war the British Flax and Hemp Growers' Society was formed, to administer a grant from the Development Fund for the purpose of conducting experiments in the cultivation and separation of flax and hemp fibre, in order to ascertain the commercial possibilities of these industries in Great Britain. Experimental stations were started at Yeovil and at Selby, a few hundred acres of flax were grown, and much most excellent research work was done, and this work, as far as was possible, was continued even during the war.

We were dependent on Russia for about 80 per cent. of the flax fibre we used, and when in 1917 the Russian Revolution broke out, and the Baltic Provinces and the flax water-retted districts of Russia were overrun by the Germans, it was realised that we were faced with a great shortage of flax, and that it was necessary to increase the acreage in this country as quickly as possible, not only because of the industry, but because flax goods, such as aeroplane fabrics, Royal Navy canvas, tent duck, etc., were urgently required for the carrying on of the war. Ireland was able to respond to the necessity by increasing the area under flax in 1918 by 36,000 acres, and the Boards of Agriculture in England and Scotland, assisted by the British Flax and Hemp Growers' Society, arranged for nearly 14,000 acres being grown in England and Scotland. Very great credit indeed is due to the Boards of Agriculture and to the Flax Growers' Society and also to the Office of Works, which has been associated with them, for the energy and efficiency displayed in the growing, harvesting, and preparation of flax in Great Britain, and for the success obtained in spite of at times almost overwhelming difficulties.

We are still faced with probably a world shortage of flax, and although happily the necessity for war materials has ceased, the flax trade, owing to the shortage and the very high price of material, is in a very precarious position at the present time. Difficulties, however, are only created to be overcome, and it is to be most fervently hoped that troubles in Russia will soon cease and we shall therefore be able to procure some of the flax which certainly is still there. Meantime, by encouraging the growth of flax in our Empire—a matter which is presently engaging the attention of Government—it is hoped we shall, in the not very far distant future, be able materially to augment, if not entirely supply, the fibre needs of the flax industry.

Cultivation.

Flax can be grown on any good medium land, but the land must be clean; light or sandy soil and heavy clay land are not suitable. But the selection of the land is not nearly so important

as its proper preparation prior to sowing the seed.

The land must be deeply worked and firm, with a shallow surface layer to cover the seed after sowing. This is important, as the crop grows very rapidly, the growing period only extending over eleven to thirteen weeks. The success of the flax crop depends mostly on the proper preparation of the land, and on the seed employed.

In the rotation of crops, one of the best periods for the introduction of flax is soon after the land is broken up from grass. It does well immediately after newly ploughed pasture, as it is little affected by wire worm, but it can also be grown after oats, roots or potatoes.

The land must in every case be well harrowed and rolled, to obtain a fine tilth and an even surface, so that the straws may be of similar length.

Flax has generally been looked upon as a dirty and exhausting crop, but if good, properly cleaned seed is sown it cannot be a dirty crop, and numerous tests have proved that the amount of plant food it takes from the land is very similar to that taken by oats and wheat.

The truth probably is, that as flax is pulled and not reaped the land looks dirty, because all the weeds are left standing in the ground, and although it is really not an exhausting crop, it certainly is a non-restorative crop, and the seed being saved for sowing, and the straw for fibre nothing goes back to the land.

In Canada and British East Africa flax is looked on as one of the best crops for clearing the land, and very good crops of grain are often got after several successive crops of flax on virgin soil.

Artificial manures, judicially used, give good results; potash is much used in Ireland, and a light dressing of sulphate of ammonia is beneficial on some soils, though as a rule, if the ground selected for sowing is in good heart, no manure is necessary.

The sowing is best done broadcast, at the rate of about two bushels to the acre, and the time for sowing varies from the third week in March to the end of April.

After sowing, the seed should be covered by harrowing with a light harrow, with closely set teeth, and then lightly rolled. When the plants are about 3 in. high the land should be weeded. If the flax has been sown on really clean land, this will not be an arduous task, as only large weeds, such as charlock, docks, and thistles will require attention; but if the land is dirty the weeding is a most tedious process. When flax is sown for seed only, it is allowed to come to maturity, but when sown for fibre it is harvested before it is ripe, when the lower part of the stem is changing colour from green to yellow, and the leaves to about half-way up the stem have changed colour and fallen; at this stage the seeds are also changing in colour from green to a greenish brown. If harvested at this time the best results can be got, both for fibre and seed, as the seed matures and ripens on the stook. If it were harvested when it had come to maturity, the seed would be good; but much of the natural sap in the straw would be lost.

Most flax-growing countries have been dependent upon Russia for the supply of seed, and in this country we have used mostly Pernan Crown, a Russian seed, and Riga Child or Riga Grandchild, these being Russian seed sown for two or three seasons, generally in Holland, and often called Dutch seed. The germination should be 90 per cent., and the purity 98 per cent. It is very essential to sow only seed of good germination and great purity.

Harvesting.

Flax is pulled, not reaped or cut, the reason being that if cut all the weeds would be cut with it, and this would cause endless trouble and deterioration to the fibre in the further preparation. Up to the present time this pulling has been done entirely by hand, a lengthy and tedious process; but several pulling machines have recently been invented, and although these are presently hardly more than in their experimental stages, without doubt they will in the near future be perfected, and will revolutionise the growing of flax for fibre in this country.

When flax is pulled, the straws of similar lengths must be arranged with stems parallel and tied up into neat bundles or small sheaves by twisting a few of the stems round them below the seed bolls. These sheaves are then set on end in the field to dry, and to allow the after ripening of the seed, after which the crop is put into a rick or the seed taken off. There are several methods of removing the seed from the straw.

By rippling—that is, drawing the bolls off through a vertical iron comb. The collected bolls can subsequently be passed between rollers or flailed to remove the seed. This rather tedious method has the merit of leaving the flax straw in the best condition for subsequent operations, and as the bolls are unbroken the seeds of weeds can easily be removed.

By deseeding—that is, passing the top end of the straw between revolving rollers set so that the straw is hardly touched, but the seed capsules are crushed sufficiently to free the seed without damaging the straw. The advantage of this method is that the bolls are separated from the straw and the seed threshed at the same time.

In parts of Russia and Belgium the straw is spread in rows on a smooth floor and the bolls beaten with a wooden mallet. It is very unlikely, however, that this primitive method will continue to be practised. A certain amount of success has been attained by using an attachment on an ordinary threshing machine whereby the straw is debolled, crushed, winnowed, and cleaned, and it is extremely probable that some such method as this will be perfected which will by treatment where the flax is grown save the loss of seed which at present occurs when the undeseeded straw is stacked sometimes both at the farm and at the deseeding station.

Retting.

After the flax is deseeded it is stored in readiness for the next process, retting or rotting, which is an operation of the greatest importance and one in connection with which many experiments have been made, and many and various processes brought forward to remedy the defects of the primitive methods, and, if possible, to accelerate the time required for properly rotting the fibre. A certain amount of success has been attained, but it has been found that the nearer one can approach to natural methods the better the result, and the use of chemicals or the boiling of the straw or such-like methods only result in poor fibre being produced. There are two processes of retting—dew-retting and water-retting—and in both the action of heat and moisture sets up fermentation, which separates the fibres from the core, to the outside of which these are attached by a gummy or resinous matter called pectose.

The method of dew-retting is to spread the fibre on grass where it comes under the influence of rain, sun and dew. The fibre is spread thinly over the ground in regular rows, and turned over often so as to get a uniform decomposition. This process is tedious, but if properly attended to and the weather is favourable, very good results are obtained, the fibre being soft and silky. The method of water-retting is to immerse the straw in canals or slow-running streams and allow fermentation to take its natural course.

The finest flax we know, Courtrai flax, is retted in the soft warm water of the slow-running Lys, along whose banks so many notable battles have recently been fought. We have not any such river, but similar results can be obtained by warm water retting in tanks. These tanks, which must have no lime in their composition, are generally made with a false bottom. The flax straw is placed vertically in the tanks the root ends downwards, and beams are placed on top to keep it down. The soluble substances and dirt from the roots are dissolved and washed out of the straw by the water and sink through the false bottom. The flow of water can be regulated so that the motion is slow, and the liquids of different densities do not mix; an overflow is also arranged for at the top of the tank. Modern experiments have shown that very good and even retting can be done by keeping a constant slow flow of water heated to a temperature of about 70° to 75° F. This appears sensible, as it is about the summer heat of water. Retting at a higher temperature tends to injure the fibre, although it must be admitted that excellent results have been obtained in recent years with water at 95° F., but great care has to be taken not to over-ret. At a temperature of 70° to 75° F. the time taken for retting is about seven days. Flax should never be retted below 60° F.; if it is, a very coarse, harsh fibre results. Friesland flax is said to be retted in brackish water, but all other flax is retted in fresh water.

After the flax is properly retted, this being determined when it is found that the fibre separates easily from the woody core, it is lifted from the tanks and the water allowed to drain off for a few hours. When first taken from the steep it is soft and spongy, but soon hardens sufficiently to be moved to field or shelter for drying.

In summer the straw is easily dried by standing it in beets in the open, but in our uncertain climate it is better to provide shelter from rain and wind. Many experiments have been made in artificial drying, but although it is believed this can now be accomplished without injuring the fibre, it has yet to be proved that it can be done economically. When properly dry the flax is passed between rollers to break the woody core, which can then be more easily knocked away from the fibre, and this is done by the final cleaning process called "scutching," and the better broken the straw is the easier will be this final process.

Scutching.

The ordinary method of scutching is performed by taking a handful of retted and broken straw, called a st ike, holding it over an upright board, and striking it repeatedly in a downward direction with a thin wooden blade held in the other hand.

The more modern method is to have the wooden blades on a power-driven revolving shaft; the scutcher feeds the strike which he holds in his hand over a rest, and when one end has been properly cleaned he reverses the strike.

These scutching mills are very simple and save much labour. The wooden blades or swords, generally five in number in Ireland and up to twelve in Belgium, are fixed on the power-driven shaft every few feet, and opposite each stall which is occupied by a scutcher. The whole is closed over with wood, and the dust, etc., can be removed by means of a fan. A certain quantity of fibre is knocked out of the strikes along with the wood, and this is called tow or codilla, which is partly rescutched and graded. The wood and the dust can be used as fuel for heating the water for the tanks. The flax fibre obtained from these operations is then made up in bales ready for the spinning mill. Before leaving the preparation stages it is well to state that in the working of flax the best results are got when the fibre is given a rest between each and every process.

Yield.

Flax when grown for seed only is sown thinly, about one-half to three-quarters of a bushel per acre, and the plants have room to branch, and give more capsules and seed; but when grown for fibre it is sown much more thickly—about two bushels to the acre—necessitating the growth of a straight stem, which is essential for good fibre. Grown for fibre at two bushels per acre, the yield on an average on fair land will be 2½ to 3 tons of straw and seed, and this will probably give roughly 6 cwt. of seed, 4 cwt. of scutched flax, and 1 cwt. of scutched tow, the balance being waste which, however, is not all lost, as much of it can be used in the furnace for heating the water for steeping. The water from the retting tanks is also useful as a liquid manure.

Spinning.

It is not possible, without slides or drawings, and difficult even with them, to give to non-technical people an intelligible description of complicated mechanical operations, but a general description of spinning and weaving will probaby be of interest.

From the earliest days flax fibres have been drawn out and twisted into yarn for the purpose of making twines, ropes and woven fabrics.

The earliest appliance used was the spindle, and this is found depicted in old Egyptian drawings and paintings, and several of the actual spindles used in the times of the Pharaohs are to be seen in museums. One which is in the British Museum was found in a tomb at Thebes, and has still some linen thread on it.

The primitive wooden spindle was from 9 to 15 in. long, rounded, and tapered at both ends. At one end there was a notch in which the flax was caught while undergoing the twisting process, and near the other end a bulb of wood or clay was secured, to give momentum and steadiness to the revolving spindle. This was called a wharve or whorl (c.f. whirl). The flax to be spun was wound round a piece of wood called a rock or distaff, which was generally held under the left arm, and the spindle itself, after having flax from the distaff attached to its notch, was laid on the right thigh and made to rotate by drawing the right hand quickly over it. As the spindle continued to revolve in the air, or like a top on the floor, the fibre was drawn out by the hands from the distaff and twisted into a thread so long as the spindle continued to revolve. When the spindle came to rest the twisted yarn was wound round it, and it was again rotated from the thigh and the fibre again drawn out, twisted and wound round the spindle until it was filled, and the quantity it held gives the name to a now definite measure of linen yarn, namely, the spindle of 14,400 yards.

The wonderful dexterity obtained by spinners using this simple and primitive apparatus was extraordinary, and they were able to produce yarns of a levelness and delicacy unobtainable even by elaborate modern machinery, linen yarns being produced by hand-spinning of over 800 lea, that is, weighing 1 oz. for over eight miles of yarn.

Changes in modern spinning have had for their objects the rotating of the spindle by mechanical means, the automatic drawing out of the fibres, and with the combination of these the working of a group of spindles together.

One of the first improvements was the cutting of a groove in the wharve, and passing a band round this, and also round a large wheel, which was rotated by hand This was known as the "bobbing wheel," and was used in various forms even up to the beginning of the nineteenth

century. When fine yarns were made they received two spinnings. The first consisted in drawing out and slightly twisting the fibres into what is still known as a rove, and by the second spinning the rove was fully attenuated and twisted.

In the sixteenth century the axis of the large wheel was cranked, and a treadle added, whereby the spinner was able to rotate the spindle with her foot, and have both hands free for the drawing out of the fibre. Later in the same century a wooden flyer with forked legs was fixed to the end of the spindle, and a bobbin or double-flanged spool was slipped on the spindle, and having one of its flanges grooved was sometimes driven separately. The fibre was drawn through an eye in the flyer, led along one of its legs and fastened to the bobbin. The flyer was driven at a higher speed than the bobbin, and twisted the fibres about a common axis once for each revolution, and the bobbin wound up the length thus spun. Sometimes the bobbin was only driven by friction, fitting closely on the spindle and being kept back by the strain of the thread only turned as fast as the spinner, judging the amount of twist required, allowed. This machine was called the Saxony wheel, and by it spinning became a continuous instead of an intermittent operation.

During the seventeenth century a second spindle and flyer were added, and the spinner was thereby enabled to spin two yarns at once, one with each hand.

The problem which remained was how mechanically the fibre could be drawn out and twisted uniformly, and the successful solution of this problem changed not only the character of the textile manufactures, but the social habits of the whole people.

In 1738 Lewis Paul, assisted by John Wyatt, invented and patented a process of drawing out fibres by passing between pairs of parallel rollers, each succeeding pair of which moved faster than the preceding pair. In order to draw out and twist the fibres at one operation, the attempt was made to turn the rollers simultaneously about their vertical and horizontal axes, and twenty years later Paul patented the use of one pair of rollers working in conjunction with a bobbin driven faster than the rollers, and which drew, twisted and wound the thread.

Neither of these was commercially successful. Many others laboured on the problem, but it is generally conceded that Richard Arkwright, a barber of Preston, achieved what others had striven for, and was successful where others had failed. What he really did was to combine Paul's drawing rollers with the spindle flyer and bobbin of the Saxony wheel, group the spindles and rollers in sets of four, and drive by water-power. This machine was called the Water Twist Frame, and patents were taken out in 1769 and 1775.

A few years earlier James Hargreave invented the spinning jenny, by the aid of which many threads could be spun simultaneously by one person. The spindles were placed vertically and rotated from a drum, and the rovings were mounted on a movable carriage, which was slowly drawn out by one hand while the spindles were revolved by the other. The inward run of the carriage enabled the spun threads to be wound on the spindles.

During the years 1774 to 1779, Samuel Crompton combined in the mule the drawing rollers of Paul with the stretching of Hargreave. Since this time there has been a host of inventors and adapters, but all modern systems of spinning are based on the inventions of Paul, Arkwright, Hargreave and Crompton.

Many of the later experiments had been made with cotton, but in 1787 John Kendrew, optician, and Thomas Porthouse, clockmaker—both of Darlington—patented, as they described it, "a mill or machine, upon new principles for spinning yarn from hemp, tow, flax or wool." This machine, or grouping of machines, appears to have been an adaptation of Arkwright's patents, and the sliver from the last series of drawing rollers was deposited in thirty-six cans, and in an untwisted state was carried through retaining and drawing rollers to the flyer and spindle. Each spinning frame had thirty-six spindles, divided into six heads, each of which could be stopped. Later the sliver was twisted, and the modern flax spinning frame is, except for numerous small improvements, worked exactly on these principles.

Kendrew and Porthouse erected a mill on the River Skrene at Darlington in 1787, and this is believed to be the first mill erected for the spinning of flax by machinery, though in the same year a mill was erected at Bervie, in Scotland, and the machinery was obtained from Kendrew and Porthouse, who also supervised the erection.

Within a very few years flax-spinning mills were erected at Leeds, and this locality became the headquarters of flax-spinning in England. Many small mills were also soon started in Scotland, principally in Fifeshire and Forfarshire. Some of the county gentlemen took an

interest in the new industry, and one certainly attended the mill daily, and also frequently the yarn market at Forfar, which was thought singular for a country gentleman of high standing, and more accustomed to fashionable life and country sports than to anything like flax spinning. It is quaintly reported in an old chronicle that he was welcomed by the manufacturers, among whom, being portly, he looked a nobleman; but he was no match for them at bargain making!

At Leeds and Dundee steam-power was early employed, but most of the small country mills were driven by water-power.

Up to 1810 a few small mills had their spinning frames of twenty or thirty spindles driven by blind men, who stood at the end of the frame with a crank in their hand connected with a moving board under their feet, one or both being worked at a time. As fourteen hours were worked at this time, every day except Sunday, it is not surprising to learn that the driver had to have a rest of a few minutes every hour.

It was not till the year 1828 that flax-spinning machinery was started in Ireland, that is, forty years later than both in England and Scotland; but Ireland soon made up for lost time, and by 1862 had nearly 600,000 flax spindles, which have now been increased to just short of 1,000,000, whereas in England and Scotland the flax spindles in 1862 were 620,000, and to-day under 200,000.

Leeds, at one time the headquarters of flax spinning in Great Britian, had, in 1864, 198,000 spindles running, rather more than at present in the whole of England and Scotland. Now she has none.

Heckling and Carding.

The first operation when the scutched flax reaches the modern spinning mill is heckling, that is, separating and subdividing the numerous small flax fibres and removing the coarse fibre by combing over a steel toothed heckle. Hand heckling was carried out by throwing the end of a strike or handful of flax over the steel comb or heckle, and pulling the strike through the teeth, repeating this process as long as is required, and then reversing and throwing the other end of the strike over the heckle. The same operation is then repeated over finer heckles, until the requisite fineness has been obtained. The heckled flax is called eight, ten, twelve, sixteen, etc., heckle, designating over which heckle it has been finished, the eight heckle having eight pins to the square inch, the twelve heckle twelve pins to the square inch, and so on, and the short fibre which is combed out is called tow.

Hand heckling is now almost a thing of the past, and machine heckling is generally practised, the flax being held in grippers and the heckle pins fixed on a revolving sheet drawn through it. The modern heckling machine, with automatic attachment which screws and unscrews the grippers, and turns the flax in order that both ends may be heckled, is one of the most up-to-date and labour-saving devices of modern times.

The processes which follow heckling are spreading, drawing, and roving, and, as already explained, these processes draw out and straighten the fibres into continuous slivers, which are mixed and again drawn out, until a level rove has been obtained; the methods adopted at the present day are similar to those mentioned in tracing the mechanical growth of machinery for spinning, but the sliver is carried forward between the retaining and drawing rollers on a series of bars fitted with steel pins (called Gill pins from the name of the man who invented them). These bars are driven a little faster than the retaining roller, and considerably slower than the drawing roller, so that the fibres being pulled through the pins are increasingly divided and straightened out.

This process is repeated at least three times, on each occasion a number of slivers being placed together, so that irregularities are equalised and a level rove, and thereby a level yarn procured.

The present spinning frame is a simple machine, whereby the twisted sliver or rove is passed between retaining rollers on to drawing rollers, moving at a greater speed, and thence through the throttle of the spindle over the arm of the flier on to the spinning bobbin, which is filled evenly by being raised and lowered automatically on the spindle.

The twist put on the yarn is such that the fibres will rather break than slide over each other.

Spinning in England and Scotland is mostly dry spinning, whereas in Ireland wet spinning is generally practised. The wet spinning frame is fitted between the retaining and drawing rollers, with a trough holding warm water through which the rove passes. The action of the warm water on the fibre and gum enables finer counts to be spun.

Tow, whether scutched or heckled, is not spread but carded. That is, it is passed over large toothed cylinders with strippers and workers separating and unravelling the fibres,

and delivering a continuous sliver similar to that coming from the line spreading. Thereafter the drawing and spinning processes are the same, except that shorter reaches are required, owing to the fibre being shorter.

The yarn, when spun, is reeled or warped into chains ready for the loom, or for the bleachfield.

It is not possible to touch on the fascinating history of bleaching from earths and alkaline plants to butter milk, sulphuric acid and chlorine, but there is little doubt that the over whitening and over calendering of the present day linens is the reason why they do not wear so well as those made in our grandmothers' days.

Weaving.

Weaving is the interlacing at right angles of two or more flexible materials, of which the longitudinal are called warp, and the transverse weft. Ovid tells of a contest in skill between Minerva and Arachne, in which Minerva lost, and in revenge half killed the presumptuous maiden by striking her with a shuttle, and then repenting, allowed her to live, but changed her into a spider to spin and weave incessantly as a warning to earth-born females not to dare to show themselves more gifted than their celestial betters. As you doubtless know, spiders are called arachnidae, and have eight legs, two more than the ordinary insect, doubtless given them because of the complicated work of spinning and weaving. It is a matter for regret that we poor mortal spinners and weavers are not also specially endowed.

Probably the Egyptians invented the art of weaving, and there is certainly no handicraft more ancient or more universal. The original looms were either horizontal or upright, in both the warp was stretched on a frame and the weft threads interwoven by hand. Later, alternate warp threads were shed, leaving a space between them through which the shuttle containing the weft was passed, the warp threads being then moved up and down, interlocking the weft which was driven home by the lay. The shuttle was thrown by hand, and great dexterity was soon acquired and considerable speed.

Job says, "My days are swifter than a weaver's shuttle," but, as during his sufferings his days cannot have passed very quickly, it is doubtful if this was a compliment to the weaver.

The old hand loom weaver had his work cut out for him: not only had he to throw the shuttle dexterously and catch it in the other hand, but he had, by means of treadles, to shed the warp, and with the hand not meantime occupied with the shuttle to drive the weft home with the lay.

The present plain weaving is not nearly so arduous a task for the worker, for the warp is shed automatically, and the weft is driven across by the picker, which was invented by John Kay and patented in 1733.

Woven fabrics are very varied in texture and have an enormous range of application, from plain cloth, repp cloth and the various twills, to the damasks and other intricate weaves made by the wonderful Jacquand loom, which, although invented over one hundred years ago, is, except for a few details modified to give greater certainty of action and greater speed, still the most important invention ever applied to weaving.

In the heavier end of the flax trade, the cloth from the loom, after being calendered or mangled —that is, passed through or over heavy rollers— is ready for the market, but in the lighter end many cloths are sent to the bleachfield to be grass bleached or otherwise finished.

The first power-driven looms appear to have been started at Limehouse about 1812, but these were very few even thirty years later. By 1862 there were 4,666 power-driven looms in Ireland, and 10,066 in England and Scotland. To-day there are 37,000 in Ireland and 17,500 in England and Scotland. Ireland has five times as many flax spindles as England and Scotland, and twice as many looms, but uses roughly only the same weight of raw flax, because the goods manufactured there are so much lighter than those manufactured in the rest of the Kingdom.

General Supplies, etc.

The experience of the great war has shown the vital necessity of linen goods for the supply of the Army, Navy, and Air Service; two-thirds at least of the total quantity of flax worked in our country having been used to produce goods for these services during the war.

It is not generally realised of what great service flax has been to us in the war. Lord French, speaking in Belfast in the autumn of 1918, said: "The war in the air has been won on Belfast wings," and that is, without doubt, true; but there were also many other flax manufactures essential for the successful carrying on of war. Linen duck for tents, covers of all kinds for transports, wagons, ammunition, stores, etc., Royal Navy and Merchant Navy canvas of various numbers and weights required by the Admiralty, hangar canvas for making shelters for our aeroplanes and airships, linen threads for sewing of all

kinds and descriptions, and many other goods besides.

The linen trade was unable to supply the goods required, and many substitutes had to be resorted to, principally cotton and jute. It is not befitting for a linen spinner and manufacturer to decry other textiles, but it is an undoubted fact that the best advertisement linen ever had was when other textiles had to be used instead of it.

The increasing demands of the war supply departments necessitated, in 1917, the formation of a Flax Control Board with sub-committees in Belfast and Dundee, to ration the raw material and to license the manufacture of yarn and goods. This Board not only stimulated the normal sources of flax supply in Ireland, but arranged for Government joining with the trade in guaranteeing a large sum of money—£800,000—for cultivating an additional acreage in Ireland; and further, as the supply of fibre seed usually obtained from Russia and Holland was not only scarce but likely to be unobtainable, the Flax Control Board persuaded the Treasury to agree to sowing 30,000 acres in Canada for the production of seed only.

It is the habit to curse controls of all kinds, and no business man wishes to see them continued, but the linen trade of the United Kingdom has every reason to applaud the work done by the Flax Control Board and its committees.

The Empire Flax Growing Committee of the Board of Trade has been, for the last fifteen months, taking evidence regarding where flax can best be grown in our Empire, and its first report will shortly be issued. Enough to say that there are many places in our Empire where flax can be grown, notably British East Africa, where already a considerable quantity of land is under flax cultivation.

Now that war demands have ceased, the present position of the linen industry is lamentable. Nobody appears to require flax goods of any kind. Doubtless the very high price of the raw material, about five times the pre-war value, decreases the volume of business. Certainly the industrial unrest, the general want of confidence due to the reaction after war, and the non-settlement of peace terms, coupled with the continuance of the blockade, preventing the mending of the broken links in the chain of commerce, deter buyers from entering into fresh obligations; but with the certainty that the law of supply and demand will level prices of raw materials and goods, with the knowledge that linen is the greatest and best of all vegetable fibres, with the determination that our spindles and looms shall be worked economically to the best advantage, which must include the co-operation of labour, giving good work for good pay, we should not fear that the linen industry will not only maintain its prestige of the past but increase it in the future.

DISCUSSION.

The Chairman (Sir Frank Warner, K.B.E.), in opening the discussion, said the subject was a vast one; it could have afforded material for at least three lectures, and he wished that the author had had the opportunity of dividing it up in that way. He hoped that at some future time Mr. Norman Boase would give the members of the Society an opportunity of listening to him on the developments on the manufacturing side, with which he was so fully acquainted. His (the Chairman's) own knowledge of the flax industry was rather limited; but he had had the opportunity at the close of last year of visiting the Yeovil district and also the neighbourhood of Belfast, and he had there seen the various operations carried out. What had struck him in regard to the operations in the early stages connected with the raw material was the primitive method of treating it. The author had explained in his paper that the best method of harvesting flax was to pull it, the reason being that that avoided the gathering in of weeds at the same time. Probably the method of pulling by hand would never be equalled, but at the same time if anything could be done to develop a pulling machine it might go far to overcome the labour difficulty which was met with at harvesting time—although he was not sure that any machine could be devised which would overcome the difficulty of pulling up weeds at the same time as it pulled up the flax. The same thought had struck him in regard to the retting process—that the ordinary retting which was carried on by farmers for so many generations was a very primitive one. The attempts which were now being made to establish retting tanks in localities where the farmers could bring their flax and dispose of it to a professional retter might go far to making the flax industry a more popular one with the farmers. There was no doubt that in connection with that there was room for scientific research. Research might not succeed in solving every trouble, but if it did no more than doing away with the nauseous odour of retting it would, from his point of view, achieve something. He did not know how far modern scientific research had dealt with the question, but the retting of flax was something on the same lines as the de-gumming of silk, and he thought it might easily be found that our raw materials might yield to a scientific treatment of the problem. At the present time, however, processes were liable to be of the "Do it quick and do it cheap" variety, without regard to the qualities of the fibre concerned. He thought that would be found true of the later stages of the

linen—at all events it was true of the treatment that one's cuffs and collars received at the hands of the modern laundry. Another point which anyone who had had to deal with the subject would be struck with, was the great opening there was for mechanical improvement in all the earlier stages of pulling, de-seeding and scutching. Attempts had, of course, been made recently which did great credit to those who had taken part in them, but as yet the threshold only had been crossed into the great wide world of possible achievement. One great thing which the flax industry in this country had to face was the cheap labour in Russia, and that he was convinced could be met and overcome only by labour-saving appliances and machinery in this country. If the same amount of inventive skill was applied to arts of peace as had been applied to the arts of war he was confident that we should win in the flax industry as we had won in more difficult and apparently more hopeless circumstances. He would like to say one word on the importance of flax supply in time of war. As the author had pointed out, flax had proved of national importance, and if that had been the case in time of war it should not be forgotten in time of peace. Twelve months ago we had been fighting with our backs to the wall for our very existence. We had had a narrow escape. We were told that there would be no "next time" with regard to war. That was a very optimistic way of looking at it, but he did not think too much reliance should be placed upon it. Great Britain must not lose its rural arts; if it did it would become like the gentle reindeer—an easy prey to the wolves and wild dogs of the nations of the world.

Major E. H. M. Leggett, R.E., D.S.O., speaking as a flax grower as well as a Fellow of the Society, said that it had been a great advantage to him to listen to the paper. It had dealt with the subject from prehistoric times up to the present day. It showed that the flax industry had been of everlasting importance from primitive man up to so-called civilisation as shown in the art of war. Flax had been a necessity all through the ages. All knew what a great part had been taken in the development of flax by the Chairman and the author, two of the most prominent members of the Empire Flax Growing Committee, and by other organisations, which had resulted in an increased output of flax, and thereby of the raw material required for aeroplane wings in particular, and which had enabled the war in the air to be won, as quoted in the paper, on wings from Belfast. The Chairman and the author deserved more thanks than in these days of censorship had been extended to them, because their duties and functions could not be made public. The author had referred to the temporary state of depression in the linen trade. It had to be borne in mind that even before the war there were certain tendencies at work which threatened to some extent, if not seriously, the welfare of the linen industry. The prices of linens had been perhaps getting somewhat above what the public could readily pay, and consequently the output of linen had not been as great as it might have been. What had been the cause of that tendency? He suggested it was the cost of raw material and the difficulty of getting it. The foundation of the trade was the supply of raw material. The British Empire was in the happy position of having within itself the real key to a commanding position in the linen industry and all that went with it. In countries within the British Empire were enormous areas of land suitable for the growing of flax, and not only land but suitable labour. England and Ireland had both proved suitable for the growing of flax, and it might be asked, why, then, had the output fallen off? On that point he thought the author might have given a lot of valuable information. He (the speaker) thought that the question of the cost of labour was at the bottom of it. In the remoter parts of the British Empire there were fortunately immense numbers of very satisfactory forms of labour—in India and in East Africa particularly —which had not such high ideas of the value of their work that they required to be paid such a wage that their products could not be sold at, comparatively speaking, a low price. The danger of being dependent on Russia was two-fold; firstly, because it was a country from which, for some years to come at least, the supplies would be irregular, and because also it was a country of cheap labour and consequently was able to produce flax at a low price, which was what the flax industry needed, but which meant also that the money passed out of the British Empire. Without going into fiscal questions, no doubt all would be agreed, whatever their political views, that they would prefer to buy from within the Empire than from outside. Our Empire, therefore, had the advantage over other countries in that it possessed immense areas of suitable lands and immense numbers of entirely suitable flax-growers. What else, then, was required? It was required to see what was necessary to induce those countries to take up flax-growing. There were points of technical education; there were points of supply of suitable seed, but chiefly there was the need for propaganda which would inform the people of those countries of the value of the product and the immense demand there was for it, and the assured market that they would get for it under the system which Mr. Bonar Law had mentioned within the last few days—the system of preference for raw materials produced within the British Empire. He felt, without touching on politics, that in that statement, coupled with the question of flax, was the solution of the difficulties of the linen trade. He would just like to hint at one political aspect. Was it not worthy of thought that the equilibrium of Ireland depended to a great extent upon the industrial welfare of the North of Ireland? And what were the great industrial interests of the

North of Ireland? They were shipbuilding and flax-spinning. With ample supplies of flax at suitable prices, the linen industry of Belfast could make strides which should employ more and more people at good wages in a state of contentment and prosperity. Raw material was at the root of the whole question. He suggested that it was necessary to go a little further than had been done already by the Flax Association, which had hitherto looked into the flax-growing possibilities of Great Britain only. Why not of the Empire? He hoped the Chairman and the author would be able to get the Association to take that broader view, and look outside the British Isles for a field for its work. He might mention that the Parliamentary Under-Secretary of State for the Colonies, Colonel Amery, only the previous day had asked him to take such opportunities as might come his way of suggesting to the flax world the desirability of getting together the strongest possible Association for studying and encouraging and helping and pushing forward flax growing throughout the British Empire. He gave that message as Colonel Amery had given it to him, and he trusted that many present in the room would assist in carrying it out, and perhaps the Chairman and the author might be looked to to take the lead.

MR. W. GAVIN said the subject of the growing of flax was so wide that one could only regard it from one's own point of view. He himself was particularly concerned with the production of flax in Great Britain, and he was afraid he was a little perturbed to hear from the last speaker that there was such a vast source of labour in other parts of the Empire which was prepared to work for very small wages, because the greatest difficulty in the production of flax in this country was the question of labour. He desired to make a very urgent demand for the encouragement of flax-growing in this country, especially in the direction of mechanical improvements. He was certain that if only the difficulties could be surmounted of taking off the seed on the farm, mechanical means invented for the pulling of the crop, and improved methods adopted of handling the crop in the factories, the growing of flax in Great Britain would go ahead, and would be a very valuable addition to those smaller rural industries which everyone desired to see established in our villages.

MR. EDWIN WIGGLESWORTH thought all flax producers were very much indebted to the Flax Production Branch for the valuable research work which had been conducted both at Selby and at Yeovil, and, whatever might be the future action of the Government in regard to the Government growing of flax, he trusted that that research work would always be continued. It had been of great benefit, and there was much further investigation, which could be carried out by the Government, and which could not be undertaken by private firms. For instance, in regard to the question of pulling machines, private concerns had made certain pulling machines, and had undoubtedly borne a good deal of expense without much result so far. Then, with regard to de-seeding, anybody who had grown flax had learnt to appreciate the immense volume of work required in the handling of a crop, which might be from two to three tons per acre. A thousand acres meant three thousand tons of material to be handled into de-seeding or out of de-seeding, and therefore any process which could do the de-seeding near the spot where the flax was grown would be an immense benefit, and result in a great saving of cost. Then there was the process of retting, which took from seven to fourteen days. New processes had been evolved, and gave promise of great economies in that respect. For instance, bacteriological retting might reduce the process to forty-eight or seventy-two hours. The labour question was a very vital one to the flax industry. Though he thought that the countries with cheap labour would undoubtedly be able to provide very large supplies of much-needed flax to this country, the industry in Ireland and England and Scotland would still be wanted, and could produce the finer and better qualities of flax. There was no reason why this country should be dependent on Belgium and Holland for the very fine qualities of flax. Great Britain could produce the necessary quantity of very fine flax, and he thought the future of the industry here lay on those lines. He looked to East Africa and other countries with cheap labour, cheap land, and climatic advantages, to produce the large volume of flax necessary for the bulk of the trade, and if those supplies came forward we could then be independent of Russia. Russia was in a chaotic condition at present, and nobody knew what would be the condition of labour when order was restored in that country. East Africa alone had at least 100,000 acres of suitable flax land, and development there was proceeding as fast as possible. He desired to take the present opportunity of expressing the great appreciation of the valuable assistance which had been rendered to the industry by the Flax Control Board and by the Empire Flax Growing Commission, and, in fact, by all the Government departments with whom one came into contact in connection with flax development.

MR. H. A. McFERRAN pointed out that in Ireland the whole of the work was done by the farmer. What the Board of Agriculture had been trying to do in England was to encourage the working of the process on factory lines. That was a most important thing, and one, he thought, which would do more than any other to develop the flax industry in this country. The factory process had to be worked economically. Drying, he thought, was one of the most important points in the process, and he believed that problem was well on the way to solution. If it was solved, he

believed that the cost of running a factory would be very materially reduced. Again, the old scutch wheel by which wood was removed from the fibre was one of the most antiquated systems there could possibly be, and it was necessary on the grounds of economy for it to be done away with entirely, and some new process adopted.

Professor John A. Todd remarked that he could not talk about flax without dragging in cotton. He thought that the inter-relation between the different fibres was one of the most interesting aspects of the whole question. It was not merely a question of the historical inter-relation between the two, but a question of the immediate present, and also of the future. The historical relation was extremely interesting. He wondered if the author remembered when he spoke of the fact that many of the later experiments in weaving had been made on cotton, that as a matter of fact those experiments had been made in Nottingham. Hargreave and Arkwright had both carried out their inventions in Nottingham. The reason why they went there when they had been driven out of Lancashire was that Nottingham had then the biggest textile industry in the whole of the United Kingdom, namely, the hosiery trade, through which she earned her great reputation for mechanical work. The inventions of the cotton trade had been made in Nottingham. The relation came out again in a very interesting way when Arkwright finally succeeded in getting hard spun yarn out of cotton. The first difficulty that he had been up against was that he suddenly discovered there was an old Act of Parliament which prohibited the making of cotton cloth in this country. Arkwright succeeded in getting over the difficulty of the Act of Parliament, but then found himself up against another trouble. The Lancashire men, out of jealousy, would not touch his product, and he had to turn to the hosiery trade and get them to use cotton yarn in place of wool, and so cotton came up against wool in the hosiery trade. With regard to the inter-relation of the two fibres, a great deal which was interesting in that connection was in the paper, but one point not mentioned was the use of cotton for aeroplane wings. That had been a peculiar feature of the war—that although our people had religiously refused to try cotton for aeroplane wings, other people had been very glad to do so. There was no doubt about it that linen was best, but it was an open question whether cotton would not be good enough. The Germans had had to use many other things much more unsatisfactory than cotton. The questions of the relations between linen and other fibres, both of cotton and others, was one for the future. There was no doubt about it that cotton was driving linen out before the war, because cotton was largely a black man's crop and flax a white man's crop. Now, thanks to the development of East Africa and other places, that was likely to change. In the meantime the total supplies of textiles of all kinds were so short that there could be no question of competition between any textiles for a long time to come. There was an ample demand in the world for any textile of any kind that could be produced, so there was no doubt that whatever the position of flax might have been before the war, it had come into its own again, and there would be no question of cotton driving linen out for any purposes at all. But if in the future there came a time of a big supply or an over supply of textiles generally, the whole question then of whether linen or cotton would come in cheaper was going to be on an entirely new basis if the production of flax could be developed on a large scale and with reasonably cheap labour in the Empire. He would like to point out that in spite of all that was being done to develop the production of cotton within the Empire, we were a very long way from being able to supply all our cotton requirements within the Empire. One could not help being prejudiced in favour of flax in that there was likely to be a really substantial part of the demands produced within the Empire, and, also, that it was more or less of a white man's crop—if not actually white labour, at least white supervision. He could not help being very sympathetically influenced towards flax by the fact that within the British Empire there was an enormous area of country where good crops of flax could be grown, and that it was a crop which could be handled almost entirely by men of the type of our slightly disabled soldiers. That, he thought, was one of the most attractive points of the whole matter, and it certainly was a very great advantage that flax was going to provide a means of development, and a basis for development, of those parts of our Empire which were white man's countries. The one thing needed was the spreading of accurate, reliable and authoritative information and methods in regard to our biggest industries, and on that account he particularly welcomed such papers as that which Mr. Boase had read.

A vote of thanks to the author for his interesting paper was then put and carried.

Mr. Boase, in reply, said he was sorry Major Leggett had thought he had not referred enough to the question of growing flax in the British Empire, and that Mr. Gavin had thought he had not referred enough to the question of the growing of flax in this country. He asked those gentlemen to believe that he was very sympathetic towards both those points. He most certainly thought everything ought to be done to continue the growing of flax in Great Britain and Ireland, and that everything also ought to be done to develop the growth of flax in the Empire. He agreed with Mr. McFerran that if one could possibly arrange some method by which flax could really be properly broken, scutching could be done away with altogether, or almost altogether. He would not even begin to reply to Professor Todd, because that gentleman had raised so many interesting points that if he attempted to reply to them he would keep the audience too long.

WAR AND EXPORTS.

The *Board of Trade Journal* publishes an interesting analysis of the returns relating to our export trade in the years 1913 to 1917. It was not until 1916 that the level of current prices took a striking leap upward; and it has risen continuously since. The great decline in the volume of the export trade is shown in the following table:—

Year.	Coal, Coke, and Manufactured Fuel.	All other Articles.	Total.
	Million tons.	Million tons.	Million tons.
1913 . .	76·7	15·4	92·1
1914 . .	61·8	12·5	74·3
1915 . .	45·8	9·4	55·2
1916 . .	41·2	9·5	50·7
1917 . .	37·8	6·9	44·7

In estimating the money value of the loss of our export trade in 1914-17 we must take into account not only the increase of prices and the decrease of volume, but also the natural increase in trade which would have taken place had there been no war. The figures show that our actual exports for the four years 1914 to 1917 were valued at 1,849 million pounds. If valued at the 1913 prices, however, they would amount to only 1,515·5 million pounds. It is estimated that the annual increase in volume of trade, reckoned at the 1913 prices, was valued at between 18 and 19 million pounds on the average during the ten years previous to the outbreak of the war. It is, therefore, not unreasonable to suppose that, if there had been no war, in place of exports valued at the 1913 prices at about 1,500 million pounds, we should have exported commodities to the value of between 2,200 and 2,300 million pounds.

In various Allied and neutral countries the opinion has found expression that our export trade has been kept up at the expense of our Allies, but this opinion, which was probably fostered by subtle enemy inspiration, is not supported by facts.

The export trade which remains has been very largely redistributed to meet the needs of our Allies. Its distribution by weight has not been ascertained, but the following table, showing the changes in declared money values, brings out the broad facts:—

The increases and decreases in this table must be read in relation to the changed level of prices. Measured by the quantity of goods exported, the loss of exports in the trade with the other parts of the British Empire and with neutrals would probably be expressed as 40 per cent. or more.

In the very earliest stage of the war the German advance overran the Lens and other coalfields, and the Longwy-Briey iron district of Northern France, and the districts referred to were until recently in enemy occupation. To aid France in this extremity the United Kingdom increased its export of coal and other fuel to France from 13,034,000 tons in 1913 to 19,283,000 tons in 1917, an increase of 48 per cent., in spite of a reduced output caused by the calling of thousands of coal-miners to the colours. To effect this we reduced our exports to other foreign countries and to British overseas possessions, and to maintain it the British people themselves have been rationed in respect of coal.

In the same way our exports to France of iron and steel and manufactures thereof have increased from 203,000 million tons in 1913 to 1,505,000 tons in 1917; to Italy the increase was from 14,400 tons to 209,000 tons. On the other hand, our exports to British India fell from 850,000 tons in 1913 to 119,000 tons in 1917, those to Australia from 565,000 tons to only 53,000 tons, while those to Argentine dwindled from 358,000 tons to 43,000 tons.

The changes are equally striking in the case of boots and shoes. Our exports to France during the period under review increased by 83·4 per cent., from 56,566 dozen pairs to 103,747 dozen pairs. To Italy the exports rose by no less than 604 per cent., from 25,025 dozen pairs to 176,288 dozen pairs. These increases were secured at the expense of our Colonial and neutral markets, where the decreases in exports to British South Africa, India, Australia and Argentine combined amounted to 540,741 dozen pairs, the proportionate decline being for British South Africa 60·2 per cent., for British India 76·0 per cent., for Australia 67·4 per cent., and for Argentine 86·0 per cent.

When the more effective prosecution of the war has demanded the withdrawal of ships from long-distance voyages and the earmarking of production to Allied needs, the United Kingdom has not

Distribution.	Declared Value of United Kingdom Exports.		Increase (+) or Decrease (−) in 1917 compared with 1913.	
	In 1913.	In 1917.		
	£'000.	£'000.	£'000.	Per cent.
Allies of the United Kingdom:—				
France, Italy, and Russia	61,645	187,875	+126,230	+204·8
All other Allies	112,376	83,623	− 28,753	− 25·6
Neutrals	92,777	82,925	− 9,852	− 10·6
British Dominions and Possessions	205,112	172,657	− 32,455	− 15·8
Enemy Countries	53,335	—	− 53,335	−100·0
Total	525,245	527,080	+ 1,835	+ 0·3

hesitated to yield up valuable markets. Thus between 1913 and 1917 the value of the exports of the United Kingdom to China declined by nearly one-third, while those to Japan fell by £9,000,000, or even 60 per cent. Other countries as a consequence have been able to increase largely their exports to those markets. There has been similar loss of trade to the United Kingdom and gain by foreign countries in other markets—for example, in South America, to which markets our exports have fallen by more than one-third.

DAIRY FARMING IN INDIA.

Since 1908, when a bulletin on the establishment and management of dairy farms was first published by the Department of Agriculture of the Bombay Presidency, the dairy industry has developed considerably all over India, and the Military Department especially has taken up this work very seriously, and has opened dairies and dairy farms all over India with up-to-date equipment and machinery. Even with regard to the civil population the question of supplying good milk to cities and towns has come into great prominence at present.

A bulletin has recently been issued by the Department, prepared as a guide for people intending to enter this new industry. In addition to various tables showing the prices, live weights, and average annual milk yields of cows and buffaloes, compiled from the records of the Civil Dairy, Kirkee, advice is given as to improvements in breeds of dairy cattle.

Approximately 1 lb. of cream is obtained from 6 to 8 lb. of buffalo's milk and from 10 to 12 lb. of cow's milk, and 1 lb. of butter is obtained from 12 to 14 lb. of buffalo's milk and from 20 to 24 lb. of cow's milk. This standard is, however, found to vary month by month.

According to Indian processes, 15 to 18 lb. of buffalo milk is required to produce 1 lb. of home-made buffalo butter, containing 17·45 per cent. moisture, 81·61 per cent. fat, 0·86 per cent. casein, and 0·08 per cent. ash. This butter yields about 80 per cent. of "ghee," or clarified butter, obtained by evaporating the water by boiling it on a low fire for about thirty minutes; "ghee" from fresh buffalo butter can be kept for about two to three months without any deterioration.

In outlying villages in India, where there is no demand for milk or "ghee," desiccated milk called "khawa" is prepared from whole milk from which cream is partially removed by setting it in shallow pans. The milk is boiled in large open vessels until most of the water is driven off. When the mass is sufficiently thick, it is allowed to cool, and is made into balls and sent out to "halwais" (confectioners), who mix khawa with fine sugar and turn it into "pedhas" and "burphi," which are the favourite sweetmeats of the Indians. "Khawa" is also made from separated milk in North Guzerath. About 12 lb. of milk is required to produce 1 lb. of "khawa," but when the whole milk is fresh and unadulterated it takes only 4 lb. to produce 1 lb. of "khawa."

The business aspect of the dairy industry is discussed by the writers in detail under the following headings: Equipment, machinery, management and labour, dairy buildings, scheme for continuous supply of green fodder, recurring annual expenses, recurring expenditure on feed and maintenance of live stock, and record sheets to be kept on a dairy farm of 200 head of cattle.

OBITUARY.

THE RIGHT HON. SIR HENRY BARGRAVE DEANE.—The Right Hon. Sir Henry Bargrave Deane died on April 21st at his residence, 52, Eaton Place, at the age of seventy-two.

He was educated at Winchester and Balliol College, Oxford. In 1870 he won the International Law Essay Prize, and this was published under the title, "The Law of Blockade: its History, Present Condition, and Probable Future." Called to the Bar by the Inner Temple in 1870, he joined the South-Eastern Circuit. In 1885 he became Recorder of Margate. Taking silk in 1896, he restricted his practice to probate and divorce work. He was raised to the Bench in 1905 as Judge of the Probate, Divorce, and Admiralty Division of the High Court of Justice, a position which he held until his retirement in 1917.

He had been a member of the Royal Society of Arts since 1893.

SIR JOHN JARDINE, Bt., K.C.I.E., LL.D.—Sir John Jardine died suddenly on April 26th, at his residence, Applegarth, Godalming, in his seventy-fifth year. The third son of a Scottish border clansman, Mr. William Jardine, J.P., and brother of the late Mr. James Jardine, K.C., Sir John was born at Dunstable and educated at Christ's College, Cambridge. After leaving the University, where he gained the Chancellor's Gold Medal for English Verse, he entered the Bombay Civil Service. Six or seven years after his arrival in the country he was chosen to be Political Officer in Kathiawar, and subsequently Judicial Assistant. His next appointment was the Acting Registrarship of the Bombay High Court. While holding this post the Government selected him to be Secretary of the Commission which conducted the celebrated "quasi trial" of the then Gaekwar of Baroda, Mulharrao, accused of attempting to poison the British Resident, Colonel Phayre. Secretariat appointments followed, and he was Secretary to the Indian Government delegates for the commercial treaty relating to the Portuguese possessions in India. In 1878 he went to Burma as Judicial Commissioner, and returned to Bombay in 1885 to occupy the position of Chief Secretary to the Government; but after a few weeks he was elevated to the Bench of the local High Court as a "civilian" judge. On his retirement from the

service in 1897 he was made a Knight Commander of the Indian Empire. Outside his official work in India his chief interest was perhaps educational. In Burma he was President of the Educational Syndicate; in Bombay, Dean of Arts, Dean of Laws, and Vice-Chancellor of the University. He was also President of the Bombay Asiatic Society. His numerous publications in India included some valuable Notes on Buddhist Law, with translations of the "Burmese Law of Manu." He was M.P. for Roxburghshire from 1906 until the recent dissolution. He received his baronetcy in 1916. He was a director of the General Life Assurance Company and of several other public companies.

Sir John joined the Society in 1898, and was a valued member of the Indian Section Committee.

GENERAL NOTES.

Palm Fibre for Brushes.—Quite a fair trade has developed, writes the United States Consul-General in Hong Kong, in what is known as "palm fibre" in Hong Kong, with the United States for the manufacture of brushes. The material is the centre of the leaf stem of the small palm (*Livistona chinensis*) which grows wild over much of the South China hill country, and which is generally cultivated in some districts for its leaves—the common palm-leaf fan of commerce. The fibre is obtained simply by soaking the stem and stripping off the outside portion. The fibre in the stem is then cut into convenient lengths, and shipped in bundles of about 200 lb. each. The fibre is used locally, and, in fact, all over South China, in the manufacture of what are popularly known as "bamboo brooms," and for Chinese scrubbing-brushes and similar articles. It is usually employed in the United States in the manufacture of scrubbing-brushes, but is capable of many other uses.

Proposed New Tunnel through the Alps.—In connection with the projected line from Bordeaux to Olessa, and the expected increase of railway traffic between France and Italy, a proposal to construct a new tunnel through the Alps is being discussed. At a Franco-Italian congress held at Lyons on March 10th and 11th, three possible routes were considered, (1) through the base of Mont Cenis, (2) through Mont Blanc, and (3) through the Little St. Bernard. A majority voted for the last-named, on the ground that the elevation is lower and the approaching slopes easier. This route would not only be less costly, but would be best for goods traffic.

Perfume and Essential-oil Industry.—As a means of encouraging the perfume and essential-oil industry in Italy, it has been decreed that ground devoted to the cultivation of flowers and herbs for the purposes of these trades shall be exempted from various State imposts on land for a number of years. In 1917 the production of mint essence was about 30,000 kilos. In Piedmont and Liguria 2,000 to 2,500 kilos of essence of lavender; in Sardinia about 400 kilos of essence of thyme, 200 of myrtle, quantities of oil of absinthe (wormwood), and oil of rosemary. In Tuscany, the Florentine iris is cultivated, and in 1912 to 1913, 600 quintals of iris root were exported.

Wool.—The current number of the *Bulletin of the Imperial Institute* contains a comprehensive article on the Empire's trade in wool in its relation to the wool trade of the world. The total amount of wool produced is estimated at about 3,000 million lb., of which almost two-fifths is contributed by British countries, Australia alone producing nearly one-fifth. Of the 460 million lb. of imported wool used in this country before the war, more than three-quarters came from British sources. Nevertheless, as is pointed out, Germany was actually using more Australian and South African wool than this country. It is interesting to note also that the total consumption of wool in Germany was greater than in this country, but it was chiefly of the inferior kinds. During the three years before the war this country was exporting woollen manufactures of the average annual value of £27 million sterling. Since then the growth of the industry has been remarkable. The average annual value of the exports of woollen manufactures has increased to over £36½ million, and at present nearly twice as much wool is being used by the weaving industry as in pre-war times, and nearly the whole of it comes from within the Empire.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

May 7.—John Somerville Highfield, M.Inst.C.E., M.I.E.E., "The Supply of Electricity." Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside.

May 14.—H. Kelway-Bamber, M.V.O., "Railway Transport in the United Kingdom." Major-General Sir Philip Nash, K.C.M.G., C.B., will preside.

May 21.—Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Japanese Design."

May 28.—Harry J. Powell, "Glass-making before and during the War."

Indian Section.

Thursday afternoon, at 4.30 p.m.:—

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies in

India, with special reference to Indigo." SIR WILLIAM DUKE, G.C.I.E., K.C.S.I., will preside.

JUNE 5.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aviation as affecting India."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m. :—

MAY 27.—LIEUT.-COLONEL THE HON. SIR JOHN McCALL, M.D., LL.D., Agent-General for Tasmania, "Science and Industry in Australia."

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 5 ... Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Professor H. L. Orchard, "The One in the Many, and the Many in the One."

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Dr. S. Williams, "The Milk Industry."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5 p.m. Mr. C. O. Bannister, "Heat Treatment of Steel."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. 1. Dr. P. E. Spielmann and Mr. F. B. Jones, "The Estimation of Carbon Disulphide: A Critical Examination of the Various Methods Usually Employed." 2. Drs. P. E. Spielmann and S. P. Schotz, "The Estimation of Thiophene." 3. Dr. P. E. Spielmann and Mr. H. Wood, "The Estimation of 'Free Carbon' in Tar and Pitch."

TUESDAY, MAY 6...Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Wales and Ireland." (Lecture II.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Discussion on papers: 1. Mr. G. Hughes, "The Electrical and Mechanical Equipment of the All-Metal Cars of the Manchester-Bury Section, Lancashire and Yorkshire Railway." 2. Mr. F. E. Gobey, "All-Metal Passenger Cars for British Railways."

Photographic Society, 35, Russell-square, W.C., 7 p.m. The President, "The Carbon Process."

Röntgen Society, at the Royal Society of Medicine, 1, Wimpole-street, W., 8 p.m. "The Silvanus Thompson Memorial Lecture, by Professor W. M. Bayliss."

WEDNESDAY, MAY 7 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. J. S. Highfield, "The Supply of Electricity."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. C. Day, "Diesel Engines."

Geological Society, Burlington House, W., 5.30 p.m. Major R.W. Brock, "Observations on the Geology of Palestine."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. A.H. Allcroft, "The Roman Circus in Britain and its Purposes: Some New Identifications."

THURSDAY, MAY 8...Pottery and Glass Trades' Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Iron and Steel Institute, at the Institution of Civil Engineers, Great George-street, S.W., 10.30 a.m. (Annual Meeting.) 1. Mr. L. Greiner, "Report on the Condition of Belgian Iron and Steel Work after the German Occupation." 2. Mr. L. C. Harvey, "Use of Powdered Coal." 3. Mr. C. H. F. Bagley, "Modern Steel Metallurgy." 4. Messrs. J. H. Whiteley and A. F. Hallimond, "The Acid Hearth and Slag." 5. Mr. B. Yaneske, "Deoxidation, and the Influence of Lime on Equilibrium in the Acid Open-Hearth Furnace."

2.30 p.m. Joint Meeting with the Institution of Electrical Engineers.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. H. S. Hele-Shaw, "Clutches." (Lecture II.)

Electrical Engineers, Institution of, Victoria Embankment, W.C., 2.30 p.m. (Joint Meeting with the Iron and Steel Institute.) 1. Mr. J. Bibby, "Developments in Iron and Steel Electric Furnaces." 2. Mr. W. H. Booth, "The Booth-Hall Electric Furnace." 3. Mr. H. A. Greaves, "Application of Electrical Energy to the Melting of Metals." 4. Mr. R. G. Mercer, "Electric Furnaces in the United Kingdom, 1918." 5. Mr. A. Sahlin, "A new type of Electric Furnace." 6. Mr. V. Stobie, "Large Electric Steel Melting Furnaces."

Historical Society, 22, Russell-square, W.C., 5 p.m. Mr. G. W. T. Omond, "The Question of the Netherlands in 1829-30."

China Society, at the School of Oriental Studies, Finsbury-circus, E.C., 3.30 p.m. Mr. J. P. Donovan, "The Chinese Post Office: its Origin, Progress, and Influence."

FRIDAY, MAY 9...Royal Institution, Albemarle-street, W., 5.30 p.m. Sir G. Macartney, "Chinese Turkestan: Past and Present."

Malacological Society, Burlington House, W., 6 p.m. 1. Mr. G. B. Sowerby, "On a New Species of *Ampullaria* in the Geneva Museum." 2. Dr. A. E. Boycott, "On Parthenogenesis in *Paludestrina jenkinsi*." 3. Mr. T. Iredale, "Notes on the Mollusca of Lord Howe Island."

Astronomical Society, Burlington House, W., 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. 1. Mr. A. E. Bawtree, "Demonstration of a New Method of Producing Coloured Designs upon Glass." 2. Mr. F. J. Whipple, "Absolute Scales of Pressure and Temperature." 3. Dr. A. O. Rankine, "On the Transmission of Speech by Light."

Iron and Steel Institute, at the Institution of Civil Engineers, Great George-street, S.W., 10 a.m. (Annual Meeting continued.) 1. Mr. H. M. Howe, "A Review of Work of United States National Research Council." 2. Mr. J. C. W. Humfrey, "Macro Etching and Printing." 3. Mr. J. H. Andrew, "Manufacture and Working of High-Speed Steel." 4. Messrs. J. O. Arnold and F. Ibbotson, "Molecular Constitutions of High-Speed Tool Steels, and their Correlations with Lathe Efficiencies."

2.30 p.m. 1. Mr. G. Taylor, "Some Points in the Manufacture of Files." 2. Messrs. D. Hanson and J. E. Hurst, "Improvements in the Case-hardening Process." 3. Mr. A. McCance, "Carburisation of Iron at Low Temperatures."

SATURDAY, MAY 10...Royal Institution, Albemarle-street, W., 3 p.m. Professor H. S. Foxwell, "Chapters in the Psychology of Industry." (Lecture II.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—May 2, 1919.

No. 3468. MAY 9, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd.; York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,468. VOL. LXVII.

FRIDAY, MAY 9, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 14th, at 4.30 p.m. (Ordinary Meeting.) H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom." MAJOR-GENERAL SIR PHILIP NASH, K.C.M.G., C.B., will preside.

THURSDAY, MAY 15th, at 4.30 p.m. (Indian Section.) PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies in India, with special reference to Indigo." SIR WILLIAM DUKE, G.C.I.E., K.C.S.I., will preside.

NINETEENTH ORDINARY MEETING.

Wednesday, May 7th, 1919; ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Acland, Frank E. D., M.Inst.C.E., M.Inst.M.E., London.
Cash, Henry James, A.M.I.E.E., London.
Hoole, William George, Lake Macquarie, New South Wales, Australia.
Robotham, Francis Edward, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Allen, Robert, M.A., B.Sc., M.Inst.M.M., Guildford, Surrey.
Bales, F. George, A.M.I.Mech.E., A.M.I.A.E., London.
Curr, Thomas, O.B.E., A.M.I.Mech.E., London.
Gedge, Ernest, F.R.G.S., London.
Giblett, Major Robert Harold, R.A.S.C., France.
Nancollas, Henry Philip, Llanelly.
Orme, Reginald Thomas, Derby.
Poulton, Captain Faville Clement, C.E., A.M.I.E.E., Stirling, N.B.
Ramsey, Arthur George, B.Sc., A.M.Inst.C.E., A.M.I.E.E., London.
Sarabhai, Ambalal, Ahmedabad, India.

A paper on "The Supply of Electricity" was read by Mr. JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 9th, 1919; SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., D.Sc., F.R.S., late President of the Royal College of Physicians, in the chair.

THE CHAIRMAN, in opening the meeting, said that among the problems of reconstruction there were no two things that were more important than the welfare of infants, so as to preserve our child life, and housing. No doubt a very large sum would have to be expended on those two objects; but when once the public conscience was aroused, and there was a clamour for State interference, it was always exceedingly important that there should be a clear idea of what was really wanted. In big hygienic legislation, if he might call it so, there was a tendency in these days to spend a lot of money, and it was very vital that we should, as the old Scotch theologian said, "get right on our fundamentals," and know what it was we wanted. He did not suppose that in the author's discourse that afternoon there would be any elaborate concrete proposals, but he could prophesy that the author would challenge attention to certain very homely simple propositions, and he was sure that nothing but profit could ensue from considering some of the basic principles, as he might call them, of those two important subjects.

The paper read was—

INFANT MORTALITY AND HOUSING.

By LEONARD HILL, M.B., F.R.S.,

Director, Department of Applied Physiology, Medical Research Committee.

The chief medical officer of the Board of Education reports that not less than a million children of school age are so physically or mentally defective, or diseased, as to be unable to derive reasonable benefit from the education which the State provides. At least a million recruits, said the Prime Minister, were found to be physically unfit for military service, and the winning of the war was thus jeopardised. There is sixteen years' difference between the

expectation of life at birth in a city like Manchester and the healthiest districts of England. At the age of five the difference is eleven and a half years. Between the ages of forty and fifty the death-rate in unhealthy districts is two to three times that in healthy districts (J. Brownlee *).

In the years 1911–14, 575,000 children under five years of age died in England and Wales, a quarter of all deaths at all ages. Twenty-one per cent. of children in county boroughs of the north die before the fifth year, and 9 per cent. in rural districts of the south.

The influence of rural conditions in keeping the infant death-rate low is seen in the following figures, given by Dr. Brend (Med. Res. Comm. Report No. 10):—

RATES OF INFANT MORTALITY, 1914.

	Deaths under one year per 1,000 births.
Scotland—Five western northern counties	58
Ireland—Eight western counties	50
„ Total civic unions with towns with populations of over 10,000	120·7
Rest of Ireland	63·9
Twenty-eight leading cities or urban districts	140
England—County boroughs of the north (industrial)	130
England—Rural districts of the south	66
France — Towns of 5,000 and upwards	111·4
Rest of France	57·8
New Zealand	51
Norway	65
Australia and Sweden	71

Provisionally, fifty deaths under one year per 1,000 births may be taken as the standard by which excess of infant mortality can be measured. Sixty to seventy was the actuarial standard fixed for the peerage some forty years ago by Ansell. Taking fifty as the standard, nearly 60,000 lives were lost owing, presumably, to unnatural influences in the United Kingdom in 1914. The deaths under five years in England and Wales were 106,000 in 1900–2, and 79,000 in 1910–12. Much has been done, then, in a decade to reduce child mortality.

Dr. Brend points out that the excess of infant mortality in the industrial areas over that in the rural districts is mainly due to respiratory diseases, and diarrhœa and enteritis. The excess from respiratory diseases is 153 per cent., and from diarrhœa 285 per cent., whereas the excess from developmental conditions is only 37 per cent., and from "other diseases" 90 per cent. The class "other diseases" consists mainly of non-pulmonary tuberculosis, rickets, convulsions, and so-called "overlying"—a large proportion of the last are really due to respiratory diseases.

The mortality in the first month of infant life is due chiefly to inborn weakness, and therefore has not been affected by the hygienic measures which have considerably lessened the infant mortality in the last ten years. The South of England, however, presents a quite considerably lower mortality even in the first week of life than the North (T. H. C. Stevenson *).

Nature is prodigal in the production and waste of the new born, and thus the balance is kept and no wild animal overruns the world.

Against the argument that the great mortality of infants secures the survival of the fittest, may be put the facts which prove that environment not stock controls the mortality From my observations of the professional class, and those who work in factories and mines, I am convinced that there is no difference in stock. Man is now learning to control his fecundity by artificial means, and the practice of these means is having a far more momentous influence on the future of mankind than the late war.

Searching for the cause of the higher infant mortality in cities than in rural districts, Dr. Brend points out that the earnings of the miners are much higher than those of agricultural labourers; that there is no clear relation between industrial employment of women and infant mortality; that the incidence of notifiable infectious diseases does not vary widely in urban and rural districts. He asserts that rural cottages are generally as insanitary as the worst in cities, and that the poor in rural districts are often insufficiently fed; that general malnutrition and poor physical development are widespread among mothers in the poorer parts of towns, and yet the average weight of the infant at birth and the infant mortality during the first month differ but little among social classes: as the child gets older the mortality rate in unfavourably situated classes becomes progressively higher.

Taking into account all these facts, Dr. Brend puts down the high infant mortality in industrial areas to the pollution of the air with coal and other dust, and to the diminution of light by this dust. In towns, Dr. Brend says, with little

* *Journ. Roy. Stat. Soc.*, Jan. 1919.

* *Journ. Roy. Stat. Soc.*, Jan. 1919, p. 73.

industrialism and consequent purity of the atmosphere, there is a relatively low infant mortality, and so with seaside towns "built in long strips parallel with the sea, and thus open to absolutely unpolluted air along their greatest length." There is, he finds, an outer ring of London with a low, an inner ring with a higher, and a centre with a highest infant mortality. In my opinion, this theory cannot be accepted. The German and Russian statistics are against it; so are those drawn from the city areas in this country. For example, in Finsbury the infant mortality varied from 41 to 375 in the sub-areas, the death-rate being the highest, without exception, where there was the highest percentage of poor class tenements and low standard of social life (George Newman *). In Dundee, again. the mortality is under fifty among the professional class, and 150 for the whole town. In Petrograd (1906–1915) the infant mortality was 122 in the better quarters, 279 in the industrial quarters. The figure for European Russia is 266. C. E. A. Winslow,† who cites these figures, says there are a million and a half infant deaths in Russia every year, and two-thirds of these should be preventable according to the standards set up in New York City. In 1910 the deaths under one year were 33 per cent. of deaths at all ages. He says, in Russia 70 per cent. of the men and 96 per cent. of the women are illiterate among the true Russians; 40 and 41 per cent., Germans; 48 and 47 per cent., Letts and Lithuanians; 51 and 72 per cent., Hebrews. He attributes the high mortality to the fact that the agricultural labour of women interferes with breast-feeding and maternal care.

In Saratov Province, of a group of mothers only 10 per cent. brought up babies on breast milk only. Of 2,000 women in the Province of Orel, 49 per cent. had begun artificial feeding by the end of the first month. In another district, only 1·4 per cent. nursed their babies, without the addition of other food, up to the seventh or eighth month. The remedy, says Winslow, is to be found in welfare stations to instruct mothers, and improvement in economic conditions allowing duties of maternity to be performed.

"All over America," says Sir Harry Johnston,‡ "where the negroes have long settled down as a free people, living under natural conditions, there is a preponderance of female births over male . . . In the extreme west of Jamaica the proportion of men to women is as fifty to a hundred . . . No negress can bear the idea of growing to old age without being a mother . . . Therefore the negro and mulatto men are much run after . . . The illegitimate births are 65 per cent. of the whole. The birth-rate among the negroes is about 38 per 1,000, the death-rate about 26 per 1000—"Lightly come lightly go." Out of 21,732 deaths in 1907, over 14,000, or two-thirds, were of children under five years of age . . . nearly 80 per cent. of the children's deaths are registered without the certificate of a qualified doctor. This death-rate is the result of ignorant neglect of sanitation and indifference of the parents." In Haiti there is a very high death-rate of children under five in the country districts. In Brazil there is a very high death-rate of children among negroes, negroids, and Amer-Indians. In the United States of America death takes twice the toll of negro that it takes of white babies.

The infant mortality rate in Germany in 1914 was: Prussia, 164; Saxony, 173; Bavaria, 193. The rate for twenty-six largest towns was, in 1913, 139; 1914, 153; 1915, 140; 1916, 130. It is noteworthy that the food conditions in Germany during the war, difficult as they have been, have not been associated up to 1918 with increasing infant mortality. The rate in the big towns has tended to diminish. While in Germany, as a whole, the infant rate fell from 207 in 1902 to 147 in 1912, in East Prussia it fell from 251 in 1901 to 178 in 1912. In 1915 the figure in East Prussia had risen again to 235, but fell in 1916 to 147, owing, it was thought, to welfare work. The initial war rise in Germany was marked, but not equal to that due to a hot summer.

In Bavaria the rate is higher in the small towns and rural districts than in the big towns, *e.g.* in 1913, 183 and 156; 1915, 212 and 165. In Dantzig (1915–1917) the Imperial money grants made for breast-feeding, together with welfare work, appeared to occasion the lowering of the rate from 177 to 109 among legitimate infants. The money grants alone do not suffice.* The Germans are now saying that the deaths of children of one to five years are 50 per cent., and of children five to fifteen years 55 per cent. higher (1917) than in the last year of peace.† In New York the infant death-rate

* "Medical Education in England, 1918."—Board of Education Report.

† "Public Health Reports No. 445," Washington, 1918.

‡ "The Negro in the New World."

* "Infant Welfare in Germany during the War."—Local Government Board Report, 1918.

† Medical Supplement, Medical Research Committee, April, 1919.

has been lowered, by welfare work, from 144 in 1907 to 88·8 in 1917. In Marylebone, from 190 in 1899 to 90 in 1914.

In Liverpool the rate was 130, and in the contiguous garden city, Port Sunlight, 80. The rebuilding of a slum area in Liverpool lowered the rate in this area from 300 to 167, and the general mortality from 40 to 28 (Leonard Findlay). Taking averages over large areas in England the death-rate varies as the tenth root of the density of population, and this relation remained constant from 1861 to 1900 (J. Brownlee).

With better housing, improved social conditions, education, all come into play. Dr. John Robertson lays the greatest stress on the ignorance of mothers, in poor quarters, as to what constitutes healthy and reasonable conditions for their babies.

Canvassing the women on last election day, in three Hoxton streets chosen at random, I formed the opinion that the tenement houses in these streets were a disgrace to the civilisation of this country. No breeder would tolerate such places for raising his stock.

And yet what education and clean methods of feeding may do, in spite of city environment, is shown by the following evidence cited by Dr. E. Pritchard. In 1901 the death-rate of infants attending at the consultation of the school for mothers at Ghent was 260 per 1,000. Two years later—in 1903—sterilised milk was substituted for so-called "fresh milk" in the artificial feeding of those who were not breast-fed, and the death-rate fell to 140 per 1,000. In 1907 a system of domiciliary visiting was inaugurated, and the rate fell to C0 per 1,000. In 1908 dried milk was substituted for sterilised milk, and the rate fell to 34 per 1,000.*

We have seen that the high mortality is due to excess of respiratory and digestive ailments, particularly of the latter. Proper feeding is then of paramount importance. Now there are two factors in the matter of proper feeding: (1) The right choice of food; (2) the need for food set by the expenditure of energy in keeping the body warm. The first factor has received abundant attention; the second I wish in particular to emphasise.

The rate of cooling of the body is closely connected with both causes of high infant mortality, for the cooling and evaporative power of the air acts, not only on the skin, but also upon the respiratory membrane.

The wild animal maintains itself at body temperature, in the face of the cooling power of the environment. Cool moving air is the natural stimulus to activity and appetite, to deep breathing, active circulation, thorough oxygenation, and good digestion. Hence the perfect fitness of the wild animal.

Cool air has a low vapour tension compared with warm humid air, and, when breathed, promotes evaporation from, and flow of blood and lymph through the respiratory membrane, the natural defences against infection. It is enough here to state that the mass of water vapour held in each cubic metre of saturated air is, at 32° F., 5 grammes; 60° F., 13 grammes; 100° F., 45 grammes; that the respiratory membrane keeps itself warm in the face of the cooling and evaporation of the air by the flow of arterial blood and secretion; the eyes water and the nose runs in a frosty wind; that exercise increases the breathing volume some five times, and the flow of blood and lymph through the membrane proportionately.

The tenement baby, over-clothed and confined indoors by the mother, for fear of its catching cold and to save trouble under the difficulties of tenement life—dies from digestive, nutritive, and respiratory troubles, brought on largely by the lack of adequate cooling and evaporative powers of the atmosphere.

The baby, when artificially fed, is not only fed on wrong food, but overfed under the conditions in which it is kept. No measure is taken to stimulate in it a vigorous life, digestion and growth.

Physiological research has proved conclusively that it is not the chemical impurity, but the physical conditions of close air which make for discomfort and impoverish health. It is not excess of carbonic acid, nor lack of oxygen, nor the presence of organic impurities which affect us in a crowded room, but the heat and moisture of the air. The victims of the Black Hole of Calcutta died not of suffocation, but of heat stroke.

I have introduced an instrument, the kata-thermometer, by means of which there can be measured the cooling and evaporative powers of the air exerted on a surface at body temperature, the measurement being expressed in units of heat loss per square centimetre per second.*

A very wide series of observations have shown me that the cooling and evaporative powers in rooms commonly approximate to

* Porcher, "Le Lait Desseché," p. 122.

* Cf. "The Science of Ventilation and Open-air Treatment," by Leonard Hill, Med. Res. Comm. Rep. 1919.

those in tropical, humid climates so admittedly enervating to man. The dry kata-cooling power averages about 6 in ordinary rooms; the monthly mean dry kata-cooling power is over 20 in summer, and over 40 in winter, out of doors, fully exposed to wind; in Sierra Leone the figures are 7 and 12. On the low-cooling and evaporative powers, and want of open-air exercise, depends the ill-health of sedentary workers, who dwell in tenements, travel in stuffy, crowded conveyances, work in such schoolrooms or factories, eat in such canteens, and seek amusement in such cinemas. It is open air and exercise, plus good feeding, which have converted weedy citizens into robust soldiers, which restore the weakly in open-air schools, and the consumptive in sanatoria.

While high buildings and close cramping together of buildings shut out the free movement of the air in big towns, the people occupy tenement dwellings, wherein the air is stagnant, humid, warm, and the cooling and drying powers exerted on the respiratory tract and skin are low: dwellings wherein the infants are often over-clothed, and where they are not exposed to anything like the same extent to the cooling and evaporative power of the wind as they are in west coast and rural cottages of Britain. Round the latter the wind blows freely. Owing to the mild climate, during daytime the door is often open, and the elder girl of the family often nurses the baby outside in the open air. More important than all, the baby is breast-fed.

Custom puts the same, or even more clothes on the town infant as on the rural infant. The people are traditionally brought up to fear the open air, and seek a debilitating degree of warmth. Not only infants, but many young children are wrapped up in a most absurd number of garments, instead of running bare-legged and bare-foot as the peasant children of Ireland and Scotland, or the children of Australia: these children are more blown upon by every wind, cooled and buffeted by every blast, while the town children live in the stagnant air of tenement, school, chapel, and cinema.

In the towns where Dr. Brend points out the mortality is low, the houses are low and more wind-swept.

The radiant heat of the sun and the invigorating, cooling and drying power of the wind are the health factors of seaside and mountain resorts. These are kept out by high buildings and close courts.

The difference between the cooling and evaporative powers at my cottage fully exposed to wind on the east coast cliff and a tenement in a confined city court is very great. The postman says that the cliff cottage situation is "two coats colder" than the sheltered village street. The wind blows through the cliff cottage howsoever the cracks and crannies of doors and windows are stopped up, and becomes wearisome in its persistence, and the high cooling power at times makes it an effort to keep warm. So must the cottages of Connaught and the Shetlands be almost ceaselessly ventilated, while those of the rural districts of southern England are, on the average, far more exposed to wind and ventilation than the close tenements of industrial cities.

In the children's ward of the London Hospital the following readings—those of the atmosphere being taken near the infants' heads—were found on winter days:—

Temperature. Dry bulb.	Temperature. Wet bulb.	Kata-thermometer. Cooling power. Dry.	Kata-thermometer. Cooling power. Wet.	Surface temperature of infant's cheek.
12–15° C.	9–11° C.	5–7·5	12–19	30·5–33° C.

Compare the case of a baby sleeping out of doors in a London court in a perambulator on a sunny, cold winter day. The readings were:

1° C.	0·51° C.	19·9	31	23·5° C.

How vastly more stimulating to metabolism the open air than the ward. This child was doing remarkably well.

In Mrs. Arthur Boake's model crêche at Stratford, E., on a March day, infants were sleeping, some out of doors, others in a room freely open. The dry kata-cooling power was 21 outside and 11 inside. The cheek temperature of the infants was 19–21° C, outside, and 25–28° C. inside. The children do very well in such cool environment.

With a heap of clothes on them the babies' bodies are surrounded with air at 30·5–35·5° C. —such are the readings taken under the babies' napkins, and the wet bulb is almost as high, 30·5–33·8° C.—a tropical, still, humid atmosphere. In the warm humid air of a crowded tenement the one cooling surface left free to the baby — the head, and this is bonneted and often veiled—is exposed to the same tropical atmosphere.

In the case of a baby kept all day, as it commonly is, in cradle and pram, stilled by bottle or comforter whenever it cries, and made quiet by the warm, humid atmosphere which surrounds it, nothing is done to secure the natural massage of its belly organs, by its movements and the deeper breathing excited thereby, to maintain the capillary-venous circulation by

the pumping action of the voluntary and involuntary muscles; to keep up the condition of muscular tone which, by tautly confining the body within the skin and each organ within its capsule, secures the support of the capillary vascular area and keeps it a well-drained irrigation system, and does not let it expand into a stagnant bog; to stimulate heat production and a fuller ventilation of the lungs and consequent better flushing of the organs with oxygen; to secure full utilisation of the products of digestion and maintain a clean bowel and keen appetite.

Colonel Butler Harris, speaking with the experience of twenty years' practice in a suburban rural district, said to me: "The custom is to put the baby's cradle in the kitchen by the fire, in the fuggiest, most airless corner, and cover the baby with heaps of clothes. When the baby gets a 'cold' the windows are shut, the kitchen fire made up, and the cradle put actually in front of the fire, and the child is not only not undressed and washed, but its chest is covered with Russian tallow and brown paper. The family eat, live, cook, iron clothes, keep food in the kitchen, and in the summer flies abound. The child is found unclean, smelling, and in a profuse sweat, and under these conditions is almost sure to die. Rarely, if the grandmother is away, a young mother may be persuaded to set a fire in the bedroom, open the window, and put the baby there."

Sir Thomas Barlow tells me he has noticed the very great delicacy of children over one year brought up in central heated houses of North America and Russia in uniform warm, stagnant atmospheres. "Children, too," he says, "have done very much better since treated on hospital balconies."

Of Germany's rural districts it is reported: "Plenty of fresh air there may be in the open country, and in the fine houses of the landowners, but not in the huts of the peasants. where a single room, with small windows which can seldom be opened, serves as living and sleeping place for the whole family, and often for animals as well. Above all, there is a lack of cleanliness . . . The effect of breast-feeding is spoilt by the irregular way in which the children are often fed. Women working all day in the fields are apt to feed their children only at night, leaving them during the day with something to suck."

In Bavaria the highest infant mortality is in the region of the Upper Danube.* The upper waters run through a quite peculiar district. The valley is wide—except actually in Hohenzollern itself—but the mountainous and wooded district of the Black Forest to the north and north-west, say, ten to fifteen miles north of the river, keeps northerly and north-westerly winds completely out of the valley all the way from Sigmaringen to Ulm. As to the infants' clothing, they are always tied up on to a cushion in the South German style. That is to say, the infants in the stagnant hot summer of this district are overclothed and stifled with humid heat.

Contrast the blacks of Australia, whose infants are naked from birth, crawl naked in the open air, ride naked, or in a mat, on the shoulder of their mothers, and only nestle with them at night into bark shelters.

The ancient Lacedæmonians did not swaddle their infants, and brought up a hardy, virile race; their children were allowed only one garment.

Plato condemned swaddling, which still persists.

The tenacity of life of the newly born is very great. Kittens may be restored after prolonged immersion in cold water, chickens and ducklings when almost moribund from cold. In the *Cape Times* there was reported the case of an infant found upon the veldt a mile away from Murraysburg, which, abandoned by its parents, had lain there, newly born and naked, for sixty-four hours, enduring a frosty night, a day of hot sunshine, and a day of rain, and survived without damage. In the wild state the infant is naturally exposed to cold at the moment of its birth until the mother can shelter it and warm it with her body, and then her sheltering and warming leaves part of the infant exposed.

Darwin describes the naked mother standing in the cold sleet in Tierra-del-Fuego, with the naked babe in her arms. Here we have the picture of an excessive exposure, in spite of which, and the extreme difficulties of feeding, the people survive. How little exposure kills the infants is shown by the fact that the Tierra-del-Fuegians practise infanticide to keep the population down to the level of the food supply. Europeans unconsciously practise infanticide through the conditions of the tenements, and in place of quickly strangling expose them to massive infection and reduce their nutrition and resistance to disease.

If, as Dr. Brend thinks, the atmosphere were so impure and dust-laden as to be injurious to

* M. Greenwood and J. W. Brown, *Journal of Hygiene*, 1912, 12. 5.

the respiratory tract of infants, it would affect the death-rate of those who inhale it while living an open life in cities, but this is not the case. The higher apes at the Zoo died of phthisis so long as they were exposed to infection from humans. Put behind glass screens they remain healthy.

The mortality rate of miners shows no special injurious quality in coal dust. Coal-miners do not suffer from phthisis, as gannister and tin miners do who breathe free silica dust. At the most, coal dust causes an "asthma" in middle age, arising from diminished expansion of the lungs, brought about by the accumulating of dust in the lungs. This mechanical effect takes years to develop, it cannot act quickly on the lungs of the infant and young child.

There is no evidence that the soot-polluted atmosphere kills mice and rats, or the pets of industrial towns. I know of no evidence of a high mortality among young animals bred in laboratory animal houses in the heart of London; guinea-pigs, rabbits, rats and mice, well looked after as they are, appear to flourish exceedingly. The high rate of metabolism of these small animals necessitates a rapid breathing, thus their lungs should be loaded up and damaged with soot and fumes more easily than the lungs of infants. These animals are fed on natural fresh foods, and kept in cool, well-ventilated houses, they are not stifled with clothes and stagnant over-heated atmospheres.

In West Ireland the hovels are built on the peat bog, on a sea-board open to the Atlantic—hovels with a peat fire ceaselessly burning on the hearthstone, and the smoke ascending to a hole in the roof. The air in these is for ever contaminated with the products of combustion; eddies of smoke scent the atmosphere with the smell of burning peat. The small cow and the pig occupy the far end and the fowls roost on the beams. The dung of these animals contains no germs pathogenic for man. The people defecate in places well removed from the hovels, so that sanitation in this respect is rough but good. The smoke pollution of the air which is breathed by the children, who huddle round and sleep close to these peat fires, cannot be much less than that endured by the inhabitants of industrial towns, and yet it is among these people that infant mortality reaches so low a rate. Their infants are saved by breast-feeding and exposure to open air.

Industrial workers, smiths and others, who work in furnace-heated places, with much radiant heat, but big openings for ventilation, and air contaminated by combustion fumes, are particularly healthy (E. L. Collis). They have conditions of radiant heat and abundant drying, cooling moving air.

The infant death-rate from respiratory disease rises rapidly in the winter months. Dr. Brend says: "It is possible that this is not due to the cold to which we generally attribute it, but to the increased pollution of the atmosphere from the large number of fires, and the precipitation of solid material in foggy weather." Evidence is cited that deaths from respiratory disease increase in London and in Glasgow in foggy weather.

Now dark, chilly, foggy weather necessitates the continuous use of gas light, fires, etc., and leads to the closing of windows. The artificial lights add to the humidity and heat of the room. In rural districts there is far more daylight, and far less artificial light is used, and therefore there is less exposure to warm, moist, stagnant atmospheres. The exposure to massive infection from carriers of respiratory disease is much greater in such atmospheres.

Infection is spread from spray coughed, sneezed, and spoken out, and dust from soiled clothes. From such arise the epidemics of colds which sweep through the community. They begin as soon as the chill weather of autumn compels the shutting of windows and lighting of fires. The cause of "colds" is the indoor conditions which spread infection and lessen resistance, not the outdoor conditions, for soldiers and sailors, exposed to the worst weather conditions, suffer least from such.

Products of combustion, to which the mist particles cling, may have a slight irritating effect on the respiratory membrane, resulting in increased secretion; but there is some evidence that this is protective.

Those exposed to sulphur fumes, oxides of nitrogen, traces of poison gases, ozone-air, *e.g.* commercial gas-makers, etc., are freer from influenza and colds than others. Chemical manufacturers have a low phthisis mortality rate.

Snuffs, smelling-salts, and sprays which enhance secretion are used to prevent infection by influenza.

Smokers are not harmed by moderate smoking; the secretion of the respiratory membrane may be thereby kept up in sedentary indoor workers, smoking being indulged in to counterbalance the effects of neglect of open-air exercise.

The Royal Commission of Scotland on Physical Deterioration of the Race, found 50 per cent. of town children affected with adenoids, or other pathological conditions of the nose and throat. The explanation is, I maintain, to be found in close air, which, while increasing infection, diminishes metabolism and vigour, while lessening the natural cleansing mechanism of the respiratory membrane by reducing the evaporation from and arterial blood flow through it.

The death-rate of infants from diarrhœa is notably increased by hot summers. This is because the warm, moist, stagnant atmosphere in the tenements and courts of industrial towns acts adversely: (1) on the infant's metabolism; (2) on the cleanness of the milk in the case of the artificially fed. The infant is heat stifled, and evaporation from its skin checked, muscular tone, voluntary and involuntary, relaxed, the circulation enfeebled, heat loss and metabolism are together brought to a low level, in consequence food is not absorbed and there results excessive bacterial fermentation in the bowels.

An inquiry which M. Flack, D. Hargood-Ash and I have made* into the metabolism of adults sitting still out of doors, in ordinary clothing, shows that the cooling powers of the atmosphere on cold breezy days increases the heat loss 100 and even 200 per cent. Richet says the baby's metabolism is lowered 40 per cent. by a warm atmosphere, *e.g.* a room at 25° C. in place of 18° C.

The activity of digestion, absorption, and clean healthy state of the bowel, depend on the heat loss and the food consumed being in proper relation. The heat-stifled baby is over fed.

In the artificially fed, the milk is soured by the warm atmosphere, and the unclean food adds to the mischief set up by the reduction of metabolism.

The temperature co-efficient of bacterial multiplication is similar to that governing ordinary chemical processes—namely, two to three for 10° C., "but, as bacterial multiplication proceeds logarithmically, a comparatively small change in rate is sufficient to produce a large difference in the number of organisms contained in, say, an infected milk if an interval of some hours elapses between inoculation and drinking. Thus, if *n bacilli coli* be inoculated in milk at 60° F. and 70° F. respectively, the number after twelve hours will be 126 *n* and 4,000 *n* respectively."*

Summer diarrhœa epidemics depend on external conditions of atmosphere, which not only depress metabolism and absorption, but favour the development of pathogenic germs in the environment and the soiling of food by dust and flies.

Children are overclothed and overfed, says Graham Lusk, when the first wave of the summer diarrhœa epidemic strikes New York City.

The mothers lose their children by seeking to save them by over-coddling and feeding. What tragedies follow superstitious beliefs and want of knowledge!

I believe the depression of metabolism is also a potent cause of metabolic deficiency, diseases, such as scurvy and rickets. If the diet is deficient in vitamines, the lessened absorption of these may turn the scale; or if, as some think, the vitamines come into play as the neutralisers of toxins produced by bacterial decomposition, an excessive decomposition of unabsorbed food may turn the scale. So, too, deficient absorption of protein may rob the infant of those amino-acid building stones necessary for growth.

Recent research has drawn an ever-increasing attention to the accessory dietetic factors—the so-called vitamines. We are adjusted to live on fresh, natural foods, plant and animal tissues (not miller's separated products), and these contain countless substances other than proteins, carbohydrates, and fats (Gowland Hopkins). Rickets, scurvy, beri-beri, pellagra, and many unrecognised pathological conditions are produced by lack of one or other of these substances, some of which are necessary for maintaining metabolism and others for growth.

Vitamines are of two types: (1) Water soluble, found in tissues which contain active cells, in the embryonic parts of plants, germ of cereals, yeast, milk, egg, glandular epithelium; (2) fat soluble, constituents of active cells, but not in store fat—*e.g.* lard, nut-margarine; present in milk, cream, butter, egg yolk, cod-liver oil, oil of other glandular tissue, edible green parts of plants.

Of the water soluble vitamines those which prevent scurvy are easily destroyed by cooking, those which prevent beri-beri not so.

If white rats are fed on pure milk protein,

* *Proceedings of the Physiological Society*, February 23rd, 1899

* Janet Lane Claypon, *Journal of Hygiene*, 1909, 9. 239.

starch, sugar, fat, and the inorganic salts of milk, there soon results a lethargic condition, unsleek coat, cessation of growth, decline, and death. A few milligrammes of yeast or wheat-germ a day restore them to full health. If dogs are fed on peas-meal and cotton-seed oil there result diarrhœa, dermatitis, delirium, and death—the symptoms of pellagra. Butter-fat cures them like magic. The British garrison in Kut, when rationed on white flour, suffered from beri-beri. The disease disappeared on their sharing in the coarse grain of the Indian soldiers.

Pellagra, prevalent in Turkish prisoners fed chiefly on maize, is cured by broadening the diet. Xeropthalmia, occurring in Scandinavian children fed on cereals and skimmed milk, is cured by the addition of cream or cod-liver oil.

Puppies fed on a certain deficient amount of bread and milk get rickets. The addition of butter-fat prevents this (E. Mellanby).*

Scurvy resulting from a diet of over-cooked and preserved food is at once cured by the addition of fresh vegetables, raw or lightly boiled, orange juice, or the juice of turnips.†

The milk of stall-fed cows is poor in vitamines. City mothers fed on vitamine-fed food yield milk poor in vitamine (E. Mellanby). When babies are fed on diluted cow's milk sweetened by sugar, the water soluble vitamines are brought low in amount. If the appetite fails deficiency may result, and then endless dietetic troubles follow. It is not improbable that a large part of the difficulties of artificially feeding babies is due to this cause.

In addition to vitamines, experiments on the feeding of rats and chickens have shown that for adequate growth a suitable supply of certain amino-acids must be available in the diet. These are the building-stones of the proteins, and proteins vary in their content of essential ones. A ration which fails to yield these in reasonable abundance cannot promote the synthesis of new protein, that is growth; but if the other (non-protein) dietary factors are suitable, increment of weight can promptly be brought about by the addition of these essential amino-acids.

Adequate growth has never been obtained with rations in which the nitrogenous components fail to furnish sufficient proportions of tryptophane,‡ lysine, or cystine; hence the significance of supplementing one food by another, and of stimulating metabolism by exercise and cooling, so that enough food is eaten to secure the growth principles.

If the intake of the protein is kept low a plane will ultimately be reached where the yield of the amino-acids in question becomes so small that it cannot satisfy, first, the growth requirement; and, later, the maintenance need for certain physiological functions, even though the other amino-acids are still available in suitable quantity.*

The minimum protein value for growth is lower for lactalbumin than for casein, for many rats even 50 per cent. lower. Human milk, in comparison with cow milk, contains a higher proportion of lactalbumin and less casein.

The artificially fed slum child may then fail to secure sufficient vitamines and amino-acids necessary for growth. Animals fed with a ration sufficiently low in protein to approach the minimum required for maintenance lose weight until equilibrium is reached at a somewhat lower level—that is, with less live cells to maintain. "When the protein concentration of the food becomes very low the animals do not eat satisfactorily, and frequently fail to respond to moderate increments of protein intake which ought promptly to induce renewed growth"—their digestive and absorptive organs have become weakened.†

After periods of suppression of growth by deficient feeding, growth may proceed at an exaggerated rate for a considerable period, and the average normal weight thus be regained. Growth arrested by an infective illness may similarly be made good.‡ Albino rats may be stunted on a diet right in quality, but deficient in energy value for a large portion of their natural life, and yet grow to full size on an adequate diet.

The procreative functions are not necessarily impaired by such stunting if continued up to the age at which breeding is ordinarily possible. If the rats are then fed up to their normal size breeding may continue to a later period of life than usual, the menopause be postponed, and life may be of somewhat longer span after such a stunting period. It is a startling conclusion that life and the breeding period may be

* *Lancet*, March 15th, 1919.

† H. Chick and others, *Bioch. Journal*, Vol. XII. 131. 1918. T. B. Osborne and L. B. Mendel, *Journal of Biological Medicine*, Vol. XXXIV. 1918.

‡ E. G. Willcock and F. G. Hopkins, *Journal of Physiology*, Vol. XXXV. 88. 1906.

* T. B. Osborne and L. B. Mendel, *Journal of Biological Chemistry*, Vol. XXIII. 1915; XXV. 1916.

† T. B. Osborne and L. B. Mendel, *Journal of Biological Chemistry*, Vol. XXVI. 1916.

‡ T. B. Osborne and L. B. Mendel, *American Journal of Physiology*, Vol. XL. 16. 1916.

prolonged by delaying the growth period.* Suppose this holds good for enemy children stunted by our blockade!

In Glasgow Miss M. Ferguson † found rickets affect something like 50 per cent. of the poorer class of children. The age incidence is six to eighteen months. It develops in the late winter and spring months. The diet does not appear to be the sole cause, inadequate ventilation and exercise are potent factors. Diarrhœa was present in 33 per cent. of the rachitic, and in 11 per cent. of the non-rachitic. She records the following :—

	Percentage of 200 cases of marked rickets.	Percentage of 150 cases of mild rickets.	Percentage of 200 non-rachitic children.
Child not taken out	45	41·5	4
Child out little .	23	16	9·5
Child out sufficiently (visitor's opinion). . .	32	42·5	86·5

The mothers' statements in regard to taking out rachitic children were probably not trustworthy, many of these being manifestly neglected. The mothers of non-rachitic children were, as a whole, very fresh in appearance and fond of going out. In the garden cities, St. Helens and Bournville, there is very little rickets.

Finlay claims that he has produced rickets in young animals by depriving them of exercise. A similar condition has occurred in lions bred in the Zoological Gardens, and in colts too warmly stabled.

Mellanby finds that with a fully adequate diet, confinement will not produce rachitic symptoms in puppies. But the puppies were not clothed, they did not live, as a babe, in a cradle, smothered with clothes, in a warm moist environment.

Puppies require to be caged in warm, moist atmospheres to make their conditions comparable.

If the diet is barely adequate and the metabolism lowered, and digestion disturbed by environmental conditions, dietetic inadequacy must result.

The effective therapeutic measures, then, for rickets are a properly balanced diet and an open-air life, together with massage and exercise, which will create the physiological demand for food, its healthy digestion, absorption, and utilisation.

Coupled no less with children's metabolism, and the healthy state of the alimentary canal, is the decay of teeth, from which 80 to 90 per cent. of London County Council school children are said to suffer. In the annual report of the Chief Medical Officer, Board of Education, 1912, the diet is regarded as of first importance in this regard to the health of the teeth, while the immediate cause of dental disease is attributed to the accumulation about the teeth of fermentable carbohydrate material, owing to this being taken in a form which does not act as a cleanser of the teeth. Natural foods are teeth cleansers. The character of the diet is the important factor. The predisposing causes are, I believe, an unhealthy state of the mouth and malnutrition of the teeth produced by depressed metabolism, an ill-chosen diet, a disturbance of digestion, and lack of vitamines. The teeth of animals put on a scorbutic or rachitic diet suffer radical changes.*

Children confined indoors have a warmer mouth temperature, which favours bacterial fermentation. Just as in the case of the nose, exposure to cool, open air and exercise brings more arterial blood to the mouth and favours the outflow of cleansing and immunising secretions.

The observations of Pickerill and Champtaloup show that the bacteria in the mouth of the Maori children are much the same in number and character as in European city children, from which the conclusion seems justly drawn that the immunity of the Maori to dental caries in the Uriwera Country, N.Z., has nothing to do with lack of infecting organisms.

We must put in force the basic principles of health which prevent decay, and not treat symptoms and attempt to limit decay with tooth-brushes and antiseptic powders. No wild man or animal uses any other tooth-brush, or other drill, beyond that of the hard natural food he bites. The foods must be natural, whole foods, not the extracted produce of millers and refineries. Sugar is an artificially extracted food, which cloys the appetite away from natural foods. If taken in excess it upsets the digestion. Polished rice and white flour are robbed of the vitamines present in the whole berry. Vegetable margarine has little or none of the fat soluble vitamine present in butter and beef dripping. Prolonged cooking of tinned foods destroys antiscorbutic vitamines. Therefore, fruit and salads must be part of the child's diet, and potatoes and vegetables boiled only

* T. B. Osborne and L. B. Mendel, *Journal of Biological Chemistry*, Vol. XXIII. 439. 1915.

† Medical Research Commission Report No. 20, 1918.

* Zilva and Wells, *Proceedings of the Royal Society*, B. February 20th, 1919. Mrs. and Dr. E. Mellanby, *loc. cit.*

for a short period. White bread, jam and tea are most deficient staple foods for children.

The teeth of a dog keep clean and free from decay because his digestion is in perfect order; he is not overfed and heat-stifled (excepting the pampered pets of childless women); he lives on the scraps from his master's table, and dog-biscuit,* the latter does not appeal to appetite or establish an over-eating habit; he faces the open air in his furry coat and cannot over-clothe himself by night or day. His tongue is clean, and the natural secretions within his mouth maintain the immunity against the organisms of decay. The need to keep warm provokes in him activity and an ample circulation of well-oxygenated blood. An acid fermentation is thus impossible around his teeth. He uses no tooth-brush and suffers from no decay, no toothache.

Sound as a bell were the teeth of the old North Sea fishermen, who used to live for weeks at a time on fresh herrings, biscuits, and beer, before the days of motor-boats, white flour, and preserved meat. Their life for hardship and exposure equalled that of the savage. They used no tooth-brush. Tooth-brush drill has done nothing to lessen the decay of children's teeth (K. Pearson).

The metabolism of an infant, just as that of an adult, is related to the surface exposure. Compared with the adult, it has a small mass and large surface. The evidence † collected from the observation of recently-fed sleeping babies in calorimeters, shows that they require a food value of from 60 to 80 Calories per kilogramme of body weight per diem. Some 15 per cent. of the energy value of the food is used for growth.

Lusk says the calorific value of nineteen samples of human milk averaged 719 Calories per litre, varying from 876 with 5·2 per cent. fat to 567 with 1·8 per cent. fat. Cows' milk has a value of about 680 Calories per kilogramme. The percentage distribution of Calories is:—

	Cows' milk.	Human milk.
Protein	21·3	7·4
Fat	49·8	43·9
Milk sugar	28·9	48·7

Calf doubles its weight in 47 days; man in 180 days.

The fuel is there to be used; the average calorie value of the two milks per litre is about the same. The protein value of human milk, on the other hand, is much smaller than in cows' milk, because growth of the infant is far slower than that of the calf.

The milk indicates by its fuel value that the infant should run its metabolism at a high level, that it should not be kept too warm and too quiet all the time, but played with and exercised naked, in cool surroundings, for some part of the day.

Taking 60 Calories per kilogramme per diem as the average need of the infant, one weighing 4 kilogrammes, say 9 lb., would require 240 Calories, and one weighing 8 kilogrammes, say 18 lb., 480 Calories. Taking the average value of milk as 700, the infants require respectively 12 oz. and 24 oz. of milk per diem. Taking 80 Calories, these requirements would be increased to 15 oz. and 30 oz.

Exercise and cool air should raise the requirements to the higher level.

Now Dr. Eric Pritchard, as the result of weighing infants before and after breast-feed, has come to the conclusion that "Nature supplies the slum infant with a very restricted allowance of breast milk; if artificially fed it must be on a very restricted dietary" in accordance with its needs, and then it will fare extremely well and avoid attacks of diarrhœa even in hot weather.

The dangers for slum infants from overfeeding are greater than those which threaten better-class infants, "largely for the reason that the inside temperature of small houses and tenements has been proved to be disproportionately high."*

In hot weather the infant is made thirsty by sweating, and drinks its bottle to secure water. The food in the bottle is not needed for heat production, and so is not absorbed. It undergoes bacterial fermentation in the stomach and bowel, with consequent vomiting and diarrhœa. From thirst the infants drain their bottles dry and appear hungry at the end of a meal. This leads to the supply of a second bottle or large feed—a vicious circle.†

"The combined effect of artificial feeding," says C. E. A. Winslow, "and high atmospheric temperature is what causes the great loss of infant life from summer complaint in New York. A baby can usually live in cold weather even when fed with cow's milk; a baby can live

* The diet has proved a deficient one in war-time.

† See Graham Lusk, "The Science of Nutrition," 1918.

* E. Pritchard, "The Infant Nutrition and Management." Arnold. London, 1914.

Cf. Finkelstein, *Deutsch. Med. Wech.* 1909, No. 32, pp. 1375–1391.

† The statement has been made that breast-fed babies in hot weather secure naturally a more watery milk.—Meinert, *Deutsch. Med. Wech.*, 1888, Vol. XIV. p. 491.

through severe summer weather if it is fed at the breast. The combination is the deadly thing. I look forward to the day when there will be not only artificially cooled hospital rooms for babies, but cool day and night nurseries in the crowded tenement districts where babies can be taken . . . such a provision is quite as important, if not more important, than the provision of warm habitations in winter."

Dr. Pritchard, by test feeds, has computed that slum infants of various ages in Marylebone consume 2 to 3·4 oz. at a single feed, and 17·5 to 22·5 oz. in the twenty-four hours. He cites figures based on slum infants' test feeds observed in Marylebone, Kensington, and Queen's Hospital, which show that the breast-fed infant at three months secures 14½ to 16 oz. in the twenty-four hours, and against these he puts figures from German authorities which show that the infants, institutional and private cases, consume 26 to 28½ oz. at this age.

Provisionally accepting Pritchard's breast-feed figures as correct—the figures are so important that they urgently need confirmation by several observers—it would appear that the slum conditions may diminish the metabolism needs of the infant from, say, 27 to 15 oz. of breast milk a day, a 45 per cent. reduction. Dr. Pritchard says an infant three months old and weighing 11 lb. should require not less than 23 oz. of breast milk, or its equivalent, in twenty-four hours; an infant of six months and 16½ lb., 30oz.; an infant of nine months, 36 oz.

Rubner calculates that to construct one kilogramme of normal body substance containing 30 grammes of nitrogen and 1,722 Calories in value, the ingestion of food to the value of 4,808 Calories is required in the case of the domestic animals, but in the case of man six times that amount is needed.

It is clear, then, that only by forcing up the metabolism by exercise and cool surroundings will the infant secure sufficient building materials for vigorous growth.

The Australian native turns aside and has her baby, wraps it in a mat, slings it to her back, and half an hour later trots after the tribe which leaves her to catch up. Any healthy baby can cling to one's fingers and support its own weight. Nature designs it to cling to its mother's hair in the native state. The muscles of the baby resist massage by contracting; so in the natural carriage of infants by the mother, the baby is constantly contracting its muscles to balance the swings of the mother's movements. The infant is warmed by the mother's body, cooled by the wind, every change of posture helps the circulation of its blood.

Lieutenant Müller (of the Danish Army) has introduced special exercises for babies. While doing the exercises the parent should sing nursery rhymes, such as "See-saw, Margery Daw," etc. The time for doing the exercises is immediately after the bath. There should be two baths a day, or one morning bath and a sponging at night. The baby should do the exercises naked and on a mattress, or with a jersey on at most. The young infant must not be enticed to sit up. A little pillow must be placed below the head when the baby is laid on its side or flat on its stomach during the first months of life, when the neck is not strong. Afterwards unrestrained it will soon show its ability to sit up during the exercises. Babies enjoy and crow with delight over the kneading of their bodies after a bath.

Exercise should not be given just after a meal; let this be digested at rest.

In the first few weeks massage only is given, length and cross rubbing of the whole body. Afterwards the most important exercises for daily performance are trunk-raising with the face upwards, an exercise which tells on the belly organs and muscles. Trunk-raising with the face downwards, an exercise which develops the back muscles and gives carriage and suppleness to the figure.

Deep breathing causes the chest to grow deep, large, and broad.

Lieutenant Müller says that the gymnastic exercise of his boys took up half an hour every evening, one-third or quarter the time spent by most men over their pipes and newspapers. By his system he developed his three boys hard, strong, and splendid in physical strength and grace. In weight and chest measurement they were as big as the average British boy when three years older. He says: "When nine years old Ib followed day by day for a week, without dropping behind, a company of German soldiers on skis through the Black Forest. He was given a signed certificate by the lieutenant in command. Both he and his brother Per are very expert on skis. Last March I tried to run them tired, but they hung on, up and down, and we made in four and a half hours a round tour that, according to the ski manuals, requires a whole day. Last October Per and I walked over the Clausen Pass from Altdorf to Linthal, thirty-one miles, in nine and a half hours. Per carried his own *rücksack*, but said he was not

tired afterwards, while I, an old racing walker, was obliged to confess that I felt my legs had had enough. At three years of age Per could swim in the open Sound, and now is a thorough expert in the water. Ib has already won several swimming races against young men of fourteen to eighteen years of age."

One sees in the streets children improvise a giant-stride with a piece of rope twisted round a lamp-post, a horizontal bar out of the bent iron railing which marks the frontage of tenements. Cricket is played in the side streets, and the back wall of a brewery carries the chalk marks imitating stumps and bails, but of a preposterous height. Where are the playgrounds which the State should have provided? The Japanese have their ju-jitsu houses, open to the wind on all sides, where the young exercise themselves in the early morning.

The one great need of a child is freedom to play in the open air, untrammelled by and unnoticed by his elder.

The child of the well-to-do is tied to the apron-string of a nurse. It must not do this and it must not do that, because it will spoil its clothes; its wonderful body, the fruit of nature's workshop through ages of evolution, is sacrificed to the vagaries of fashion and vanity.

There is a vicious circle at work, for so many mothers and teachers are weak, chilly, physically undeveloped people.

The natural method of keeping up the body heat, when physical means of lessening heat loss are insufficient and active movement is not taken, is to shiver. The muscles, by shivering, produce heat, and the tone and metabolism of the muscles is kept up by shivering. We think nothing of seeing a dog shivering on a winter morning, or after a cold bath, and the dog catches no cold and suffers no harm from so doing. People are accustomed to seeing children shiver after a sea bath, are not alarmed at this, and at most only hasten their dressing. Nevertheless, there is a general fear of shivering, a fear that this means the "catching of a cold," the danger of pneumonia, etc. The shivering which accompanies a febrile infection, has become confused in the public mind with that due to cold—a normal reaction.

The natural reaction to cold makes for health, by provoking muscular tone and metabolism, and should not be suppressed to anything like the extent it is customarily suppressed by over-clothing and stagnant warm atmospheres. Young children are, by adequate exposure and exercise taken to keep warm, made strong and vigorous, impelled to grow, to develop a hard cutaneous fat (a pig partly covered with a sheep's pelt develops a soft fat with lower melting-point thereunder), hard muscles, toned up to face a hard world.

If children shiver, they should run about to make themselves warm, rather than be warmed with artificial heat. If their food supply is ample, they cannot be starved with cold nor made thin by the exercise they take to keep warm.

There takes place an obvious deterioration of health in many people of sedentary occupation, starting in October with the beginning of artificial heating and window shutting on the advent of cold weather, and proceeding through the winter. There is no evidence that a similar deterioration takes place in horses, cattle, poultry, out in the fields unclothed and when stabled in buildings freely ventilated, with dry litter, but not artificially heated. Stall life is the cause of tuberculosis in cows.

I can tell you of a home for tubercular slum children, where any month, unless there is a bitter wind, the children are more or less uncovered at intervals during the day. In the winter, after the bath, they run round the shelter (with canvas blinds) with bare legs and scant night attire and jerseys. In the summer months they go about all day with only knickers, and sleep in canvas shelters. They never show any discomfort from cold, or suffer from "colds." and come to regard going in as a punishment. They are, of course, very well fed, and do extraordinarily well. Going back to the slums they relapse again, becoming thin and pale from the caged life and ill-feeding.

In the open-air schools established for weakly children, where good food is provided, together with rest in the open air, and open-air work, the weight and health of the children increase amazingly. Cases of heart disease, nervous children easily overwrought, those in danger of tuberculosis, those subject to "colds" and coughs, are alike benefited beyond measure. Why are these schools only for the sick? There was one in New York, now there are 120. Why are the healthy left to be debilitated by a caged school life, in place of being strengthened and far more wisely trained by the methods of the open-air school? Why are the young thieves of the slums saved, and converted into healthy colonists, sailors, etc, by the good luck of being sent to reformatory schools, while the children who commit no crime are punished,

made sickly by the continuance of their evil environment?

Think of piglings at a farm, two or three weeks old, naked in an open stable, crowding for warmth round their mother, but with backs exposed, and now again having to run round to follow the sow, secure food or an inside place, and then fully exposed to the cooling power of the air. Contrast these with children, mothered by women who fear cold as the source of all evil; children over-clothed, caged in over-heated rooms. Babies smothered in cradles and prams, older children who, when not coddled at home, are confined at school, open air exercise barred to them on the slightest sign of wet, and after dark. Schools lacking playing grounds, where exercise is not made the first but the least important part of their education, where there pertains a monstrous system of punishment by confinement indoors and the writing of lines, in place of punishment by compulsory walks or runs, which would at once make the child good tempered and amenable to discipline; where the clever students are rendered feeble in physique and neurotic in temperament by the no less monstrous system of cramming for examinations, and long hours of home work. You may see the products of this system in many of the scholars sent on from council schools to a university education—poor faded creatures, a disgrace to the State which permits such folly. For twenty-five years I taught medical students, and have watched in many the degradation of health, manhood, the enthusiasm for learning, by cramming for examinations, by the absurd over-loading of the curriculum, by the total neglect of an ordered discipline of their physical health.

Cramming for examinations, homework, and neglect of daily exercise, weakens the vigour and lessens the happiness of tens of thousands of girls at the secondary schools.

The senate of a university, which insists on the subjects of an examination being passed simultaneously—I myself have been one of the guilty—deserve to be hanged in front of the university buildings, for destroying the happiness, and debilitating youth, at the time when adolescence makes most demands for a wisely disciplined life

I call to mind the case of a girl who, after cauterisation of her larynx for a tubercular infection, suffered a constriction due to scarring of the wound, which hampered her breathing so much that she could barely walk across the road without loss of breath. Continuing to lose weight, she had a thin and drawn appearance. Tracheotomy was finally done to relieve her. At once she gained in weight nearly a pound a day—and, walking miles, quickly came to a robust health. Sedentary "caged" workers may be starved, just as this girl was starved.

The physical health. the good temper, and moral behaviour of children are closely related. Cross temper is produced by over indulgence in food, and removed by a purge or a long walk. Naughtiness, and in particular fidgetiness and inattention in school, can be cured by open-air exercise. To punish such by detention, and by imposing tasks of sedentary brain work, by the very cause of the distemper, is monstrous folly.

With adults the same is no less true; dull monotony of occupation. confinement from natural modes of activity, metabolic disturbances arising from a sedentary indoor life, are great causes of ill temper, unhappiness, and moral obliquity.

In the system of education of boys instituted by Sir Rowland Hill and his brothers, and carried on by my father, a compulsory run was a punishment, the spirit of trust developed, and the cane not used.

Almond of Loretto * had the wisdom to see all this, and to turn out boys proud in the maintenance of clean physical health. He writes:—"I don't think it is so much that boys have too much brain work, as that, in many cases, they get too little oxygen. With us the almost total abolition of lines, the substitution of the cane" (used, however, very little) "in almost all cases of breach of rules, and the enforcement of abundant exercise on every boy, and, unless medically exempted, on every day and in all kinds of weather, are turning out, I am sure, many strong men into the world who would otherwise have been weaklings."

"I would consider the Chinese punishment of depriving of sleep as less dangerous than the depriving of exercise. It would be much better to put a boy on bread and water than to do that." "This pressure for scholarships and other appointments seems to me to be destroying the spontaneousness of life, physical, social, and intellectual, of the abler boys; entrance to open scholarships is a bribe to the overstraining of the minds and nerves of little boys." "What appetites we had in those days, brothers!" writes an old boy. "And what lovely complexions! But then we deserved to have them. We had not spoilt our stomachs with incessant

* "Life of Almond of Loretto." By R. J. Mackenzie.

'tuck,' or shirked the wind and rain in stormy weather, or, again, spent large parts of our play-time in doing penal tasks for outraged masters or prefects . . . Impositions were unknown . . . In our happy family life there was no great need of punishment. We blew off our superfluous energies in the open air."*

Every child must be given such opportunities by the reconstruction of industrial quarters as garden cities, built like Adelaide, in beautiful and healthful surroundings.

Labour must effect this, not make "fluff" and luxuries.

Of three acorns from the same tree, one planted on the coast and torn with every gale becomes a stunted hedge-growth barely surviving by keeping dwarfed and misshapen before the blast; another planted in an open park, sheltered from the fury of the full cutting gale, becomes a magnificent tree, and may be destined to live in full splendour of its growth five hundred years; a third, planted in a dense wood, struggles up through the undergrowth as a thin, weakly stripling, and, starved for light and air, never comes to maturity. Eight millions of the population are reported to live in one to three roomed tenements, and the head-gardener of the State has not yet seen to it that the children of the people develop in good surroundings, so that they may be hardened off into strong and beautiful forms.

Many triumph over all disadvantages in so far as they secure good food and have the streets and courts as their play places. To confine these children within the walls of schools artificially lit and heated, not only during school hours but during the play hours of winter evenings—as the philanthropists seek to do—may intensify the evil influence of their environment. The street and the open air of the street, the relatively dry pavement of the street, the romance of the lights of the street—these are the heritage of the city child.

Citizen soldiers bred in streets may long to escape back to the street; while the Highlander longs for his heather-clad hills and moors.

The cat sticks to the house it was nurtured in, whether palace or slum, and so may the man. But which should the child be nurtured in—in the garden city where he can enjoy the beauty of sky, sunshine and cloud, flower, field and tree, where he learns to love the culture of plant and animals, and open-air games and manly exercise, or the streets with their squalor and smells set off by gay shop lights reflected in wet pavements, movement, and bustle, and the cinema and music hall for his entertainment?

What do the poets sing, all the young poets the war brought forth? Of the slums and tube railways? No, of the fields and flowers, the rivers and hills, the sea, the stars, and wide expanses of the sky!

* In a memorandum of the Labour Party Education Committee on continuation schools, curricula are cited in which thirty minutes a week are given to physical exercise! Is then the new Act going to intensify the debilitating influence of city life?

DISCUSSION.

THE CHAIRMAN (Sir Thomas Barlow) said a great many of the points to which the author had referred had been more or less accepted by those who had had to deal with children and their ailments. The author, however, had tried to put those points on a real scientific basis: he had given scientific reasons to show why moving air was such an important factor in health. If the audience carried away with them from the meeting nothing more than a knowledge of the importance of moving air in the daily life of adults, children and infants, a most valuable and vital result would have been achieved. He had seen in his own earlier experience of children and infants a neglect of that necessity, and the terrible consequences which had followed. The author had referred to Mr. Almond, of Loretto School. He (the Chairman) had never been actually to that school, but he had had a great deal to do with the pupils there. He had sent several boys there who had been going to the bad, physically, in some of the public schools of this country, and the results had been most remarkable. It was quite true that Almond not only insisted on open air, but he likewise insisted on great freedom of the garments. He would not allow any of his boys to have any contraction round the neck. It had been very largely due to Almond's protest that that villainous thing, the stock, in soldier's equipment had been very much modified, because Almond had pointed out the enormous importance of free respiratory entrance. There was a good deal more attention paid now, especially among the well-to-do classes, to infant's clothing than formerly had been the case. He had several times begged his lady doctor friends to take into serious consideration the details of infant clothing. One of the most vicious things was the amount of clothing put on to infants, one of the effects of which was to lessen the respiratory movements. He particularly commended the ladies to notice the clothing of an infant with respect to its neck. One of the results of too much clothing was that the child tended to keep its mouth open instead of breathing quietly through the nose. The trachea of an infant was a very soft, flexible thing, and all the multitudinous wraps which were

put round the neck pressed upon it, with the result that after a few months, more especially in the case of handfed children, the lower parts of the chest were somewhat collapsed owing to the imperfect flow of air, due, as he thought, to the way in which the neck had been constricted. Almond of Loretto had done a great service in drawing attention to the perils of hindrance to the free respiratory inflow, and by insisting on leaving the neck much freer. The common practice, especially among the well-to-do, when a child was seen to be cold, was to heap clothes on it. That was not the way to protect a child from cold. The proper way was to encourage exercise, to reduce the clothing and let the child move its limbs about. A child should be put on its abdomen and allowed to move about. If an infant was put on its abdomen it would be seen how it threw its legs and arms about with pleasure. The proper way was not to put more clothes on it, but to rub it and use artificial friction for the extremities. That was the healthiest way of restoring the circulation. He had been much struck with what the author had said about the condition of London children in regard to their schools. He had several times broached the question to educational authorities whether the primary schools could not be built to a much greater extent on the edge of the parks. There was no earthly reason why London children should not have the advantage of the parks. People had said "We do not want to have the parks crowded with children playing their games." Why not? Why should not they have as close proximity to fresh air as possible? One of the great conclusions which would be drawn from the paper was the enormous importance of garden cities in some form or another. When one saw the difference in the health and vitality of country children and town children it was really heart-breaking. The tendency to put up great factory-like tenements such as they had in America, which, however sanitary in other respects, shut out the sunlight, was abominable, and he did hope that those who had to do with municipal affairs would not sanction such things if they could possibly help it. We wanted to get our people, and especially our children, out into the sunshine and fresh air, and to let them have moving air. We must not be afraid of moving air. It should be looked upon as a natural stimulus which encouraged exercise, and in that way promoted the only real rational kind of respiration of the circulatory and respiratory organs and the nervous system. Some very interesting facts had come out before a recent committee on the health of munition workers, on which the author and himself had sat. Women workers in big factories often had to be furnished with a room where they could lie down if they felt faint. It had been shown very convincingly that the physical vigour of women workers was not as great as that of men, but if they were given plenty of moving air—he did not say a violent draught on the neck, but a general draught so that they could feel the motion of the air—a good many fainting fits were avoided. The tuberculosis crusade had led to open windows at night, and many people were now alive to the value of open windows in railway carriages and workshops. That was especially the case with women, who needed air more than did men.

Mr. J. S. Whybin inquired if the author thought it desirable that a block of dwellings should be erected in Southwark, although it was to be centrally heated and installed with lifts? Also, did he think it desirable that living rooms should only have 8 ft. ceilings, and should open out into the scullery, where washing had to be done? Did he think, too, it was desirable that of the half million houses that were to be built, the great bulk of them should be erected almost adjacent to industrial towns?

Dr. R. King Brown remarked that for the last ten or twelve years he had been advocating similar views to those expressed by the author, very largely owing to the author's own propaganda. The author had been one of the first scientific advocates of fresh air and of moving air. It was a surprising thing that in practically all the public health books mention was scarcely ever made of the subject. The chemical composition of the air was dealt with, as also were the impurities, and so on, but there was not nearly sufficient stress laid upon the physical condition of the atmosphere. He hoped the paper would be spread far and wide, and he would certainly do his utmost in his own locality to disseminate information. He was medical officer of health for a very large industrial district, and he would certainly take the liberty of quoting the author's views in the local paper, to which he contributed a health column, and he trusted that other medical officers of health would do the same.

Dr. Norman Macfadyen said he had been medical officer of health for the garden city of Letchworth for a number of years, and he was very glad to hear the scientific basis upon which the author had put the matters dealt with in the paper. He intuitively believed that the author was perfectly right, and he rejoiced at the opportunity which had been given to Dr. Hill to develop those scientific truths. He believed he had arrived at the true method when he advocated building on garden city lines. The infant mortality at Letchworth last year had been thirty-eight, and that, for an industrial town—because Letchworth was an industrial town of about twenty factories—was an excellent record. He desired to ask the author and the chairman if they would help to secure the insertion in the Housing Bill before the House of Commons of a clause which would enable garden cities to be built, because at the present time there was no clause to that effect.

Mr. A. J. Clifford Ewen said he desired to challenge one statement of the author's. The greater part of the paper was admirable, and many of the points needed to be repeated over and over again, even to those who knew something about them; but when the author said that the citizen soldier bred in the streets longed to escape back to the sights and smells of the streets, he (the speaker) would most emphatically say that that was not the case. The citizen soldier had had just about enough of the sights and smells of the streets; he wanted the free air and the sunlight. The citizen soldier did like to get back to the streets, but he did not like to get back to the sights and smells. He went back to the street because in that street was his little home and wife and children, but he did not want the smells of it. He was asking the emigration officer how he could get to Canada, Australia and New Zealand, and this country did not want to lose the pick of its soldier citizens in that way. He (the speaker) belonged to a Worcester regiment which was composed of a very large proportion of youths who came from crowded slum areas in Birmingham and Coventry, and very few of the number he had spoken to desired to go back to those conditions of slum-life.

Mrs. A. Model said that schools situated in the slums could not be removed by a magic wand, and therefore something should be done in the way of providing roof gardens in those particular schools. That had been a matter which had been very much neglected. By such means the children would be able to obtain fresh air. Even wretched tenement buildings would be better for roof gardens, and it seemed to her that the opportunities had been neglected in that direction.

Mr. Leonard Hill, in reply, said he was very glad that the Chairman had insisted on neck freedom. Over-clothing was a point to which the greatest attention must be paid, but he would like to point out again that the low cooling power by diminishing metabolism lessened the expansion of the lungs, and reduced the breathing to perhaps half what it should be, so that all the time a child was in the low cooling power it was made to breathe in a shallow way, and added to that the neck was bound round with clothes, and so on. But it was not only a matter of the constriction of the neck. He quite agreed that garden cities should be built, and that big towns should not be added to. The Government should choose new sites with beautiful surroundings, and with all the conditions that favoured a happy and healthy life. The Government should look upon the business as of the same importance as the management of the war. Sickness was killing just as many as the war. The whole question should be gone into as boldly and as thoroughly as we had faced the war. That was the only way to get better conditions, and it was the one way in which to escape the perils which had overtaken Russia. Wages meant nothing for men if they had no opportunities of spending them properly. It was the power to live which people required to be given—not wages, but power to be happy. With regard to schools being heated with the Plenum system, there was only one way in which that system could be used, and that was to have cool natural air driven into the school through wide openings all round, about 8 feet to 10 feet up, so that it was driven in equally, and went out through the ceiling. The heating should be absolutely independent. The air should not be heated. The cool air should be allowed to come in, and never hot air. With regard to Mr. Ewen's remarks, he was quite ready to modify the sentence in the paper, and to alter it in such a way that it met with Mr. Ewen's wishes. Roof gardens were a palliative at the present time. Nothing could be better. Advantage ought to be taken of the roofs so that children could exercise upon them. The suggestion was a most valuable one, and should be carried out. He hoped everyone would fight for the establishment of garden cities. The State should possess them. They would pay in every way.

A vote of thanks to the author for his interesting paper concluded the meeting.

THE MANUFACTURE OF SOYA-BEAN OIL IN MANCHURIA.

Two processes are employed at Dairen for making oil from soya beans. One, known as the "extraction process," is a chemical method which, by the use of benzine, extracts the greatest amount of oil from the beans. When it is employed, not cake but bean meal is produced, and this is said to be preferred to cake for fertiliser, as it requires no breaking before it is used on fields. The oil, however, is said to sell for less than that produced by the "expression process," as it is difficult to remove all traces of benzine from the oil. The term soya-bean oil is generally understood to mean expressed oil.

It appears from a report by the United States Consul at Dairen that only one mill at that place uses the extraction process. This mill was built as an experiment by the South Manchuria Railway, and was subsequently sold to the firm of Suzuki & Co., of Kobe. The machinery was brought out in sections from Germany, set up by German experts, and operated by them for some months. Permission to inspect the plant must be obtained from the head office at Kobe. The extraction process of obtaining the oil is, however, well known.

Over fifty mills are using the expression process at Dairen. Usually they are open to inspection upon proper introduction. Vertical presses of four columns, of about twenty-five cakes per column, are used, some mills having double presses—presses on two floors, one directly above the other, and built as one machine, with the power applied at the same time in one operation. It is customary

to work these presses by hydraulic power. They are displacing the old hand-power screw press.

When the beans are received at the mill they are generally frozen, or very near it. After being sifted, to remove such matter as stones, dirt, etc., they are kept for several days in a warm room, where they are turned over with shovels and thoroughly mixed from time to time. No magnetic cleaning is done at any of the mills except the chemical mill, which uses this method additionally. No particular temperature is aimed at, the object being simply to warm the beans so that the oil will be more easily freed. After they have been warmed for several days, they are conveyed to the top of the crushers and run down through a series of cylindrical, smooth, or nearly smooth, iron rollers, which roll, not grind, them. They emerge as discs, the size and shape of a dime. They fall from the rollers into a trough, in which a screw conveyor is turning, and conveys them to the pressing floors, where they fall into bins.

The press gangs have ready squares of gunny-bag cloth, each of which holds a sufficient quantity of rolled beans to make a cake. The required quantity is scooped up and put into the cloth, which is then carried to the steam-box. The cloth is spread out over the steam-box, with the beans a couple of inches deep, and the steam is turned on and allowed to flow up through the mass for two or three minutes. The steam is not under pressure when applied, but escapes into the room, and no particular degree of temperature is aimed at, a thorough steaming being all that is desired, with the warming attained at the same time.

Meanwhile, several more coolies, who work naked, or with a loin cloth and sweatband only, have prepared the form. This consists of an iron plate with two handles, upon which two iron rings, which will form the cake, are placed, and two bundles of a long grass, imported for the purpose from China, are spread fanwise. Then a thin, wooden circular frame, with ends not fastened together, is placed on the grass and forced down upon the plate inside the rings, the grass ends standing upright.

The steamed beans are brought from the steam-box into the gunny cloth, and with one swing thrown into the form. A coolie, shod with the native footgear resembling a moccasin but heavier, jumps in, grasps a handhold overhead, and stamps the beans into a compact mass inside the form. He then stoops and raises the wooden holder slightly, pulls up the iron rings to their proper position, steps out, takes out the wooden frame, folds over the grass ends to form the top of the form, and lays two flat iron bars thereon to hold the grass ends in place. Then two men take plate and all to a small auxiliary press, where gentle pressure, sufficient to set the mass, is applied for a second or two; the plate with the cake on it is taken to the press, the cake shoved off the plate into one of the columns forming, and the plate brought back for another trip.

As soon as the press is full, top and bottom, a wooden post is inserted at the outer side to keep the cakes in position, and the signal is given to the engineer, who turns on the hydraulic power. The bottom of the press rises slowly, and the oil immediately begins to flow. The first pressure is not great, and as the first flow subsides more power is applied, but time must be given for the oil to run before much pressure is used. After several hours' pressure, the oil having ceased to flow even after the maximum of 130 tons per 100 cakes has been applied for a number of hours, the press is opened, and the cakes are taken out and stripped of the iron rings with instruments similar to "peavies." The grass also is removed. Coolies take the cakes between their knees, and rolling them forward in the operation, cut off the rims (the part squeezed out between the iron rings) with drawknives. This finishes the cake, which is then ready for storage and shipment.

The bottom of each cake has an indentation caused by the butts of the two grass bundles, and on the top there is imprinted the chop of the mill, which is cut out in relief on a block and put inside the cake just before the grass tops are turned down as before described.

The oil flows by gravity from the presses into receivers, from which it is pumped into storage tanks. It is first strained, and in the tank it settles and is drawn off, so that the sediment is not taken with it. Tanks are cleaned frequently, and have pipes to draw off sediment. No fuller's earth or clarifying clays are employed, nor is any other conditioning method used.

BUREAU OF MYCOLOGY.

The contents of the Imperial War Conference Blue Book (Cd. 9177, 2s. net.) include a short memorandum on the Imperial Bureau of Mycology which, on the recommendation of the Colonial Office, the Conference decided to establish for the purpose of supplementing the work of the Imperial Bureau of Entomology. The latter Bureau was the outcome of a movement set on foot ten years ago to provide more effectively for "the control of the insect pests which are the source of so much injury to agriculture and to men and animals in the oversea possessions." The Entomological Bureau is administered by a committee of distinguished experts, and its activities are described as being manifold. One feature of its work is the identification of insects sent by collectors from all parts of the world. In 1914 no less than 86,000 specimens were received. The funds of the Bureau amount to £4,346, annually made up as follows: Imperial Government, £500; Canada, £500; Australia, £300; South Africa, £350; New Zealand, £200; India, £500; Nigeria, £500; Gold Coast, £350; contributions, varying from £5 to £100, from twenty-two Colonies, Egypt, and the Sudan, £1,146. The headquarters are at the Natural History Museum; those of the

new Bureau will be at Kew, rich in specimens of fungoid diseases. As in the case of the Bureau of Entomology, there is to be a committee of competent experts and Dominion representatives, with a layman of high standing as chairman. The Bureau is to confine itself in the first instance to plant disease, but in time its scope will be extended so as to embrace other branches of agricultural development, such as plant-breeding, etc. It is estimated that a sum of not more than £2,000 per annum will be required to maintain the Bureau for the period of the war, towards which the Imperial Government are asked to contribute £250 a year on behalf of the State-aided Colonies and Protectorates; Canada, £250; India, £250; South Africa and Australia, £150 each; and New Zealand, £100; the remainder to be found by the self-supporting colonies, Egypt, and the Sudan.

MEXICAN "VEGETABLE WOOL."

Considerable interest has been shown of late in the fibre that is classified in Mexico as "pochote," but is known as "Java kapok" in the United States. The designation "vegetable wool" (*lana vegetalis*) also has been commonly applied to this product, which has been known and used by the natives of Mexico for many years, but without any special regard for its commercial value. Practically the same fibre is produced by two different species of plants, one of which is confined to the State of Tabasco, while the other may be found in large quantities in the States of Campeche, Coahuila, Colima, Chiapas, Guerrero, Morelos, Sonora, Jalisco, Michoacan, Oaxaca, Puebla, Sinaloa, Tamanlipas, Tabasco, Vera Cruz, Tepic and Yucatan.

The plants grow wild in Mexico, and begin to produce when two years old, yielding from nine to thirteen pounds of fibre annually. This fibre has never been exploited in Mexico to any considerable extent, though it is commonly employed to fill mattresses, pillows, etc. The seeds, which are similar to cotton seeds, are roasted and used as a food by the natives in the districts where the plant flourishes. Lately, however, writes the United States Vice-Consul at Mexico City, attention has been directed to the oil of the seed, which heretofore has been employed in Mexico solely for soap-making. One ton of the seed is said to produce 65 gallons of oil, which compares favourably with cotton-seed oil.

No statistics are available to show the annual production of "pochote" in Mexico, and the prices asked for the fibre vary from *5d.* to *1s.* per lb., according to the locality in which it is produced.

OBITUARY.

SIR WILLIAM HOOD TREACHER, K.C.M.G.—Sir William Hood Treacher died at St. Albans on May 3rd. He was born at Wellington, Somerset, in 1849, and after graduating at Oxford entered the Colonial Service about 1870. He became in turn Colonial Secretary at Labuan, Acting Consul-General at Brunei, and member of a mission to the Sulu Islands and North Borneo in connection with Spanish claims. In 1881 he was appointed first Governor of British North Borneo, and in 1888 Secretary to the Government at Perak. In 1892 he became British Resident at Selangor, in 1897 he was Acting Resident-General for the Federated Malay States, and for the period 1902–4 he was Resident General for the same district. He received the C.M.G. in 1890, and the K.C.M.G. on his retirement from the service in 1904.

Sir William joined the Royal Society of Arts in 1906. In the following year he read a paper before the Colonial Section on "British Malaya, with more especial reference to the Federated Malay States," and he subsequently presided at several of the Society's meetings. He served on the Council continuously from 1906-14, during the last four years as a Vice-President of the Society.

GENERAL NOTES.

X-RAYS APPLIED TO REINFORCED CONCRETE SHIP CONSTRUCTION.—The success of the concrete ship will depend largely upon the strict observance of every precaution for securing perfect concrete. Mr. A. C. Freeman, writing in the *Pacific Marine Review*, describes an application of X-rays which he has devised as a means of maintaining a constant standard of moisture and disposition of reinforcement. The procedure is, first, to show by means of a series of X-ray photographs that the standard of uniformity of mix and compactness is maintained; secondly, to observe any misplacement of reinforcing, which, recognised in time, may still be remedied; thirdly, to detect the presence of voids as the structure develops, thus permitting of their timely elimination. The outfit weighs about 90 lb., and its cost is stated not to be excessive. The method will also be valuable for examination of vessels after sea experience, with a view of detecting any flaws or deteriorations that may be developing. In connection with the experimental work involved in present-day ship construction, there is a large field of usefulness for the X-ray—in the case of electrically welded ships as well as in that of the concrete ship.

A NEW SOURCE OF TURPENTINE OIL AND RESIN.—Turpentine oil and resin are already being produced on a commercial scale in India by the distillation of pine resin. A new source of supply, which though comparatively small may be valuable, especially for Indian use, has now been found in Indian frankincense or olibanum. This material is obtained by the natives by making incisions in the stems of *Boswellia serrata*, a tree widely distributed throughout the dry zone forests of Central India. The resinous substance which exudes from the cuts contains a kind of turpentine, a resin, and a gum. Investigations of the methods of separating these constituents in a marketable form, as to their

commercial uses and value, and on the methods of tapping the tree, have been conducted since 1912 by the forest authorities in India in co-operation with the Imperial Institute, the results of which have been published recently in a paper by R. S. Pearson, Forest Economist, and Puran Singh, Chemical Adviser at the Forest Research Institute, Dehra Dun. The general conclusion reached, based on the results of numerous trials carried out in India and in this country by the Imperial Institute, is that the turpentine oil is equal to good quality American turpentine oil, and that it could be used in place of the latter in the manufacture of paints and varnishes. The Imperial Institute has also reported that the resin would be quite suitable as a substitute for pine resin (colophony) in the manufacture of varnishes, being equal in value to grade "G" of American resin.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

May 14.—H. Kelway-Bamber, M.V.O., "Railway Transport in the United Kingdom." Major-General Sir Philip Nash, K.C.M.G., C.B., will preside.

May 21.—Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Japanese Design." John Slater, F.R.I.B.A., Member of the Council of the Society, will preside.

May 28.—Harry J. Powell, "Glass-making before and during the War." Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S., Director of the National Physical Laboratory, will preside.

Indian Section.

Thursday afternoons, at 4.30 p.m.:—

May 15.—Professor H. E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Soil Deficiencies in India, with special reference to Indigo." Sir William Duke, G.C.I.E., K.C.S.I., will preside.

June 5.—Brigadier-General Lord Montagu of Beaulieu, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aviation as affecting India."

Colonial Section.

Tuesday afternoon, at 4.30 p.m.:—

May 27.—Lieut.-Colonel the Hon. Sir John McCall, M.D., LL.D., Agent-General for Tasmania, "Science and Industry in Australia."

MEETINGS FOR THE ENSUING WEEK.

Monday, May 12...Geographical Society, Burlington-gardens, W., 8.30 p.m. Mr. A. T. Battye, "Crete: its Scenery and Natural Features."

Tuesday, May 13...London Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 5 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Ireland." (Lecture III.)

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. W. C. Mann, "Development Papers and Desensitizers."

Anthropological Institute, at the Geological Society, Burlington House, W., 5 p.m. Sir Everard im Thurn, "Dwellings and Costumes of Old Fiji."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Colonel J. M. Copeman, "Experiments on Sex Determination." 2. Mr. N. Taylor, "A Unique Case of a Symmetrical Duplicity in a Chick."

Colonial Institute, Caxton Hall, Westminster, S.W., 8 p.m. Mr. T. R. Johnson, "Railway Development in Australia."

Horticultural Society, Drill Hall, Buckingham-gate, S.W., 3 p.m. Mr. V. Banks, "Bottling and Drying."

Wednesday, May 14...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. Mr. H. Kelway-Bamber, "Railway Transport in the United Kingdom."

Aëronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Captain A. P. Thurstan, "The All-Steel Aeroplane."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Major J. Erskine-Murray, "Wireless in the Royal Air Force."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Professor Sir Henry Newbolt, "Poetry and Patriotism."

Thursday, May 15...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Professor H. E. Armstrong, "Soil Deficiencies in India, with Special Reference to Indigo."

Chemical Society, Burlington House, W., 8 p.m. 1. Messrs. B. Blount and J. H. Sequeira, "'Blue John' and other forms of fluorite." 2. Mr. G. M. Bennett, "The nitration of diphenylethylenediamine." 3. Mr. D. L. Hammick, "The destruction of picric acid in nitrating acid." 4. Messrs. J. C. Irvine and J. S. Dick, "The constitution of maltose: a new example of degradation in the sugar group." 5. Messrs. R. J. Manning and M. Nierenstein, "The tannin of the Canadian hemlock (Tsuga Canadensis, Carr)."

Royal Institution, Albemarle-street, W., 3 p.m. Professor F. Keeble, "Intensive Cultivation." (Lecture I.)

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Messrs. E. A. Laidlaw and W. H. Grinsted, "The Telephone Service of Large Cities—with special reference to London."

Friday, May 16...Royal Institution, Albemarle-street, W., 5.30 p.m. Dr. S. F. Harmer, "Subantarctic Whales and Whaling."

Saturday, May 17...Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. Wells, "Caesar's Personal Character as seen in his Commentaries."

No. 3469. MAY 16, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement

Journal of the Royal Society of Arts.

No. 3,469. VOL. LXVII.

FRIDAY, MAY 16, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 21st, at 4.30 p.m. (Ordinary Meeting.) SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Japanese Design." JOHN SLATER, F.R.I.B.A., Member of the Council of the Society, will preside.

TWENTIETH ORDINARY MEETING.

Wednesday, May 14th, 1919; MAJOR-GENERAL SIR PHILIP NASH, K.C.M.G., C.B., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Chakravarti, Rai Bahadur Gyanendra Nath, I.S.O., M.A., LL.B., Benares City, India.
Gardiner, Rev. Allan Frederick, M.A., Trichinoply, South India.
Gowan, Arthur Byram, Newcastle-on-Tyne.
Hyland, Alfred, A.M.I.E.E., Bombay, India.
MacKenna, James, M.A., London and Pusa, India.
Jackson, Sir Herbert, K.B.E., F.R.S., London.
Neil, Matthew Dale, Dalla Dockyard, Burma.
Richardson, Benjamin, Wordsley, Stourbridge.
Richardson, William Haden Arthur, Wordsley, Stourbridge.
Spivey, George, A.M.I.E.E., Weymouth.
Varley, Gilbert, M.Sc., Assoc.M.Inst.C.E., Birkenhead.
Vassar-Smith, Sir Richard Vassar, Bt., D.L., J.P., London.
Williams, Richard James, A.R.C.A., Worcester.

The following candidates were balloted for and duly elected Fellows of the Society:—

Blight, Francis James, F.R.S.E., Wembley, Middlesex.
Boase, William Norman, C.B.E., St. Andrews, Fife.
Bode, Sorabjee Hormusjee, Bombay, India.
Brocklebank, Ernest, J.P., Caton, Lancaster.
De Majumdar, Indu Bhushan, Cooch Behar, Bengal.
Dyson, Rear-Admiral Charles Wilson, U.S.N., Washington, D.C., U.S.A.
Ebrahim, Ahmed Currimbhoy, Bombay, India.
Howeson, A. C. E., Calcutta, India.
King, Henry George, Lincoln.
MacGuckin, Charles John Graham, C.B.E., Assoc. M.Inst.C.E., M.I.Mech.E., Newcastle-on-Tyne.
MacLeod, James MacIver, C.M.G., Valparaiso, Chile.
Mason, William, London.
Needham, Lieut.-Colonel Joseph G., D.S.O., Didsbury, Manchester.
Paton, George William, London.
Pickthall, Frank John, Buenos Aires, Argentina.
Ritchie, Frederick George, Singapore, Straits Settlements.
Royle, Harry, Cabinda, Portuguese Congo.
Ryan, Joseph S., Montevideo, Uruguay.
Sadler, Thomas J., London.
Schneider, Charles Eugène, Paris.
Stancourt, John Augustus Frederick, London.
Suttie, P. E., Calcutta, India.
Wyer, Raymond, Worcester, Mass., U.S.A.

A paper on "Railway Transport in the United Kingdom" was read by Mr. H. KELWAY-BAMBER, M.V.O.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

Thursday afternoon, May 15th; SIR WILLIAM DUKE, G.C.I.E., K.C.S.I., in the chair. A paper on "Soil Deficiencies in India, with special reference to Indigo," was read by PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

EXTRA MEETING.

An extra meeting will be held on Monday, May 26th, when a paper on "A New Prime Mover of High Efficiency and British Origin" will be read by CAPTAIN FRANK E. D. ACLAND, M.Inst.C.E., M.I.Mech.E. The chair will be taken by the Hon. SIR CHARLES ALGERNON PARSONS, K.C.B., LL.D., D.Sc., F.R.S.

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, MAY 7th, 1919; MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council of the Society, in the chair.

The paper read was—

THE SUPPLY OF ELECTRICITY.

By JOHN SOMERVILLE HIGHFIELD, M.Inst.C.E., M.I.E.E.

In accepting the invitation of the Council to read this paper, I hardly realised what a difficult task I had undertaken. So much has been written on the subject, following on reports, both official and unofficial, that both the past history and the present position of the electric supply industry have been obscured, and the general impression left on the public mind is that the present plants for supplying electricity are so out of date as to result in absurdly high prices, and that engineers in the past invented a multiplicity of systems either to please their personal fancies or through sheer lack of vision and understanding. Both these views are wholly erroneous. In the circumstances I have endeavoured to trace in as few words as possible the history of this difficult branch of engineering and of the legislation which, in a large measure, determined the course of its development. The recent able reports on the subject have made plain to everyone the great importance of developing the use of electrical power, both from the point of view of coal conservation and for the encouragement and initiation of new industries, and now we find prospective Members of Parliament, led by the Prime Minister himself, offering to the country "cheap electricity." All this enthusiasm marks a welcome change from the rather depressing political atmosphere which enveloped the pioneers.

Despite this depressing atmosphere, the fact remains that the engineers have accomplished much. There is no town of any importance, and no area of the country which can be described as industrial, where electricity is not supplied at prices sufficiently low to attract manufacturers and other users. Before 1914, for power supply, with coal at about 10*s*. per ton, the ruling prices were about one penny per unit for ordinary factory hours and one halfpenny per unit for factories working continuously, and lower prices for special purposes under contract. The very efficient and long established gas supplies, and private plants in mills and works, all tended to restrict rapid expansion. It is common knowledge that progress was swiftest where new building and construction were most active. Allowing for the less rapid growth of our own towns and for their excellent gas supplies, it is doubtful if this country is not at least as well supplied with electricity as others where water power is not available.

The early companies working under Provisional Orders pioneered the work, and developed plant, apparatus, and cables: the value of this work is incalculable. The cost in money and effort was immense; plants and systems were scrapped unmercifully until reliable gear was available. There are few of the engineers who designed and ran the works of the companies in London, Liverpool, Leeds, Glasgow, Newcastle, and other large towns, who cannot tell many a tale of their early difficulties. They were nobly backed by the early manufacturers, Cromptons, Ferrantis, Siemens, Parkers, Callenders, the British Insulated Wire Co., Mather & Platt, the Electrical Power Storage Co., and many others. Their joint efforts resulted in producing reliable plant. Not least of the results of all this early work was the development of the Willans and Belliss engines, and the Parsons turbine which owed much to the electrical supply companies. Amply has the turbine repaid the debt; no invention has done more to provide power with small expense of coal than the Parsons turbine; none of the great developments in power supply and shipping would have been possible without it.

Just as the provisional order companies pioneered the work of electrical distribution in urban areas, so did the power companies that of long-distance transmission and distribution in extra-urban districts, where the loads were widely scattered but individually called for considerable quantities of power. In one way it may have been fortunate that municipal opposition prevented these companies from supplying in the urban areas, as it forced them to face the difficult problems of widely spread distribution.

If the electrical supply industry does not make startling progress in the future, it will not be for want of attention to the subject. There have been a series of inquiries, followed by reports, all pointing to the extreme national importance of providing a cheap and adequate supply of electricity.

Recently there have been three reports,

namely, those of the Coal Conservation Sub-Committee, the Electrical Trades Committee, and the Electric Power Supply Committee.

These reports have been, no doubt, carefully studied by all directly interested in the subject, but for those who have not studied them it may be useful to summarise some of the views expressed therein.

All the reports dwell on the great importance of distributing energy derived from coal or other sources in the form of electricity. Clause 18 of the Electric Power Supply Committee's report states:—

"It should be fully recognised that cheap electrical power is a matter of first-class importance, and will in the future be essential to the industrial progress of this country. Concentration of larger generating units in larger and fewer power stations, wherever practicable, is urgently required in order to reduce the cost of industrial power to a minimum, and to conserve coal and get the fullest value from every ton consumed."

Each of these reports refers in some detail to the causes which tended to restrict the full and natural development of the supply of electricity. The conclusion reached in each of the reports is that the popular desire that the public, through its municipal representatives, should provide its own supply, thus confining each undertaking within a municipal area, was placed before technical evidence tending to show that this policy was a mistaken one. The Electric Power Supply Committee's report states "That the present system under which a supply of electricity is provided in a large number of small areas by separate authorities, is the result of a policy adopted at a time when the applied science of electrical engineering was in its infancy, and is incompatible with anything that can be accepted now as a technically sound system." Mr. A. A. Campbell Swinton, in an article in the February number of the *Nineteenth Century* nineteen years ago, stated the same fact in other words; but the causes for the mistake were political rather than technical, as he points out.

The report of the Electrical Trades Committee, appointed by the Board of Trade, states:—

"Through the efforts of Faraday, Wheatstone, Kelvin, Swan, Hopkinson, and many others, Great Britain was, and should have continued, first in electrical enterprise. The nation's pre-eminence in all branches of engineering provided a foundation upon which the new and closely allied electrical industry might have been naturally and quickly built up... In order, however, to bring electrical energy into practical use, it was necessary to employ cables...the installation of which involved interference with streets ... Manufacturers of electrical plant have been held back while Parliament and local authorities debated how the distribution and use of electricity might be prevented from infringing conventional conceptions of public privileges and vested interests...While America, Germany and other countries were eagerly seizing the benefits of electricity, our authorities were busied with the erection of obstacles to its development. Thus for years this country stood still, leaving the field open for foreign manufacturers to gain, both in their own and other markets, a hold which they have never lost. Abroad there were strong encouragements, in Great Britain irksome restrictions, and the evil effects on the British electrical industry justly entitle it now to special remedial measures, which can be secured only by legislation. Such legislation should be passed without delay."

The mistakes made by Parliament in the legislative enactments relating to the supply of electricity arose from the fact that the authors of those Acts considered it all important that the citizens, through their elected representatives, should provide their own electricity. Had they acted up to the height of their desires they might have said that electricity shall be supplied solely by the municipal authorities, but in the days when legislation was first proposed, namely, about 1880, the whole business was in a very experimental stage, there was no knowledge to point to standardisation, there were fierce debates amongst engineers on this subject, standard plant and cables did not exist; in short, any person starting to provide a supply of electricity was forced to shoulder all the usual risks of a pioneer. Realising that a business involving such risks was an unsuitable one in which to invest public money, the Act of 1882 gave a reluctant consent to private companies to use the streets for the purpose of laying mains, but, in order to satisfy the view that municipal authorities should provide the electrical supply, three conditions were attached to the consent, viz.: (1) that the supply should be confined to the area governed by the municipality; (2) that companies supplying in neighbouring areas should be denied the right of association; and (3) that the local authorities should have the right of purchasing the undertakings at the end of twenty-one years, paying for the land, buildings, plant and cables their value at the date of purchase without any allowance for goodwill.

The result was complete stagnation until the Act was amended in 1888 by extending the term

of the lease from twenty-one to forty-two years, the other restrictive conditions remaining.

Following on this revision, a number of companies were formed and put into active operation electric supplies in many large towns, including London, Birmingham, Newcastle, Southampton, Northampton, Woolwich, Leeds, Sheffield, Glasgow, and Liverpool.

Following on the pioneering work carried out by the companies, the municipal authorities, led by the Vestry of St. Pancras, proceeded to set up electricity undertakings, and many of the undertakings initiated by companies were bought by the respective municipalities between the years 1890 and 1900.

In general, the municipalities have developed and carried on their undertakings in an efficient manner, and have served the public well, their efforts, however, being, with few and small exceptions, confined within municipal boundaries.

It was realised at a very early date that electricity would furnish means of transmitting power over far greater distances than were possible with older methods. Dr. Ferranti was the chief exponent of the principle of erecting large power stations outside the populated areas for the purpose of generating electricity to be carried into the area by means of cables. In pursuance of this principle, he laid down the famous plant at Deptford with what at that date were very large power units, and constructed a system of underground mains for bringing the power into London. The engineering difficulties at that time were immense, and in the circumstances, as everybody knows, a great technical success was achieved. The system of supply was single-phase alternating current at 83 cycles per second. At about the same time, other engineers developed the low-pressure direct-current system, the stations being, of necessity, situated near to the load.

In the earlier stages, the commercial success of the low-pressure direct-current plants exceeded that of the high-pressure alternating, and naturally the low-pressure plants predominated. The foundations of knowledge of the subject were being laid, but there were many variables in the problem and little experience; and, although now it is common to complain of the great diversity of systems in this country, it should be remembered that there was a very good reason for their origin. There were the rival claims of direct current as compared with alternating current; direct current was then more readily generated owing to the greater ease of parallel running; alternating current, on the other hand, being more easily used at high pressure and transformed to low pressure. Apart from this main discussion, there were all sorts of doubts as to other constants, as, for instance, frequency. The high frequencies were used in order to reduce the cost of transformation. At that time very little attention was given to the possibility of supplying motors, electricity being used mainly for the purpose of light, and here direct current was more suitable for arc lamps than the alternating current. There was good reason for adopting different frequencies, but there was no good reason for adopting slightly differing values for low pressures. In fact, the variations in frequency offer far greater difficulty to the joint working of different plants than the variations in pressure. There is no doubt that the effect of the Electric Lighting Acts definitely preventing association between neighbouring companies tended to encourage variations in systems. It is clear that if it had been contemplated at first that neighbouring companies might work together, more effort would have been made to employ uniform systems. It is difficult to realise now how strong were the arguments put forward on each side by the advocates of direct current and alternating current respectively, and in view of this strong difference of technical opinion, there is no wonder that uniformity of systems was not immediately attained. It was, in fact, at that date unattainable.

Soon after the original systems were started up, defects appeared.

Owing to the difficulty of selling alternating current, because of its unsuitability for arc lighting and power in competition with direct current, whole systems supplied with alternating current were scrapped and changed over to direct current.

Certain early types of plant were found to be unreliable, and were scrapped.

Distribution systems, such as those employing house transformers, were found to be uneconomical, and were scrapped.

Overhead wires were used in London; these were all scrapped.

Certain cable systems were found to be unsuitable and were scrapped.

Almost from its inception, great difficulty was experienced in coping with the demand, which was more difficult to deal with than it is to-day. It was almost entirely for lighting, and consequently in the large towns the

most violent changes occurred. A dark cloud coming over a city would cause the load to be more than doubled in a few minutes. The ability of the staff and plant to meet sudden calls was all important; this was the chief cause that brought the water-tube boiler so quickly into prominence. Power and heating have minimised this difficulty by providing a steady running load during the whole of the daylight hours, and therefore any changes in the lighting bear but a small proportion to the total.

Apart from the difficulties of dealing with these sudden loads, it was very difficult to predict twelve months beforehand what figure the next winter's demand was likely to reach, and many supply works found themselves overloaded and working under the gravest difficulty. In London, and to a lesser extent in other large towns, it became apparent that the initial works erected within the town boundaries were inadequate, and steps were promptly taken in London by the Charing Cross, Metropolitan, St. James's, and Westminster Companies to erect works outside the area of London, first to supplement the supply from the old works, and subsequently to supersede them altogether. The advantages of using large plants and the economies to be effected by concentration were fully realised, and the large capital cost necessary to effect the change was incurred without hesitation so soon as it became necessary or advisable to shut down local plants.

In spite, however, of the advantages and general economies of large plants, it was found advisable to retain some of the small ones for a number of years, and they have done very useful work during the war. The proper method of employing small plant is to confine its use to as few hours of the year as possible, to see that the engines, when running, are working at full load, and to burn the fires right down, and so waste as little fuel as possible.

The effect on the cost of changing over from inefficient small stations to larger ones is illustrated by the experience of The Metropolitan Electric Supply Company. In the year 1902 the company were completing the Willesden power station, and they had running in London, stations at Amberley Road, Manchester Square, Rathbone Place, and Sardinia Street. In 1903 steps were taken to transfer the whole of the load to the Willesden Station as quickly as possible, by replacing the local plants by suitable sub-station plants, and the change over was completed finally in 1905, the only in-town steam plant retained being at the Amberley Road station. In the result, whereas in 1902 to generate 23,000,000 units cost £114,000, in 1905 to generate 26,000,000 cost £64,000.

Other undertakings have effected similar improvement, and doubtless there remain industrial districts where like economies could be secured.

At the present time the public supply o electricity is provided by companies working under provisional orders from about the year 1888 and expiring about the year 1931. The large provincial towns are almost all supplied by their municipalities. The smaller provincial towns are supplied by Provisional Order companies and by the municipal authorities. Up to about the year 1900 the rural districts had enjoyed very little public electric supply.

In 1898, the General Power Distribution Company made the first application to Parliament for sanction to distribute electricity over a wide area. The application was rejected.

In 1899 and 1900 a number of companies were formed as power companies for the purpose of supplying electricity over areas enclosed rather by county than by municipal boundaries. These companies met with strenuous opposition from the municipal authorities with the unfortunate result that the large towns were excluded from the companies' areas of operation. The Acts obtained by these companies were an improvement on the older Acts in so far as the onerous purchase conditions were not imposed, permanent tenure being granted. There are now operating in the country twenty-one power companies supplying all the districts outside the great towns which could be regarded as offering reasonable commercial possibilities for the supply of electricity. In spite of the disabilities under which the companies work, they have made considerable progress, and during the war have performed most valuable work in supplying power for new munition factories; many industries have been started which, without their assistance, could not have been put into operation. It is a great misfortune that municipalities treated the power companies in their first beginnings as enemies. Had they, while reserving their distribution rights, encouraged the power companies by purchasing power in bulk, there is no doubt that, instead of increasing the plant on sites which in many instances were unsuitable for the purpose, a very large capital sum would have been saved,

and as a result the cost would have been reduced.

To co-ordinate the work of these different bodies the report of the Electric Power Supply Committee proposes to set up commissioners to delimit areas and generally control the expansion of the business; to leave existing suppliers to attend to distribution for the present, and to form district boards which shall purchase all the power stations and main transmission lines and erect new power stations and transmission lines to supplement and, where necessary, supersede the existing plants.

The recent publicity given to the subject has led the public to look for great reductions in prices and many other benefits to accrue from Government taking charge of the industry. With the present cost of plant, fuel and labour, no startling reductions in price can be looked for, and so much misunderstanding exists as to the cost of supplying electricity that perhaps some explanation of this subject may be useful.

The term "cheap" electricity has been freely used in recent reports and articles. Having regard to cost of production, electricity is now supplied in all industrial districts and large towns at cheap rates, the figures in Table I. being typical of average prices.

To make progress in any branch of science, the most important element is accurate measurement. Unfortunately, there is no simple means of measuring the cost of supplying electricity to enable a ready comparison to be made between one method and another or between the costs of one station and another. The readily metered Board of Trade unit is commonly taken as a measurement, and the cost of producing one unit at one station compared with the cost of producing one unit at another. Hence arise very serious errors, because the Board of Trade unit is far from being a measure of cost. Every manager of an electrical undertaking knows this fact, and frames his tariff on that knowledge. The fact remains, however, that the cost of producing the Board of Trade unit is used widely as a means of comparing the economy of one station with another. An equally common error is to use the average selling price per unit as the measure of the excellence or otherwise of an electrical undertaking. Without qualification, this method produces utterly misleading results. The average cost per unit or the average selling price can serve as a measure of comparison only when the following conditions are identical:—

(1) Area of supply covered.
(2) Number of consumers.
(3) Maximum load.
(4) Number of units sold.
(5) The time of use of the maximum load.
(6) The cost of coal.

The conditions are rarely even approximately identical, and consequently qualifying factors must be applied before any comparison based on the above measurement can be made.

The following table shows what wide variations exist in the working cost per unit sold and the average price received for electricity. Any use of either figure for the purpose of comparing the general excellence of these undertakings would be wholly erroneous.

TABLE I.

Name of Town.	Maximum load.	Cost per unit exclusive of capital charges.	Average price received per unit.	Percentage of gross profit to capital.
	kilowatt.	d.	d.	d.
Ashton-under-Lyne	2,636	0·55	0·85	7·50
Birmingham	54,930	0·91	1·28	9·46
Bury	5,128	0·55	0·82	8·10
Glasgow	55,610	0·83	1·21	8·35
Leeds	24,920	0·52	1·04	8·31
Liverpool	29,048	0·76	1·51	10·41
Sheffield	57,338	0·48	0·88	13·36
Stalybridge	9,000	0·45	0·82	11·37
City of London	21,000	1·55	2·55	7·01
County of London Company	18,500	1·42	2·19	7·14
London Company	23,300	0·80	1·06	4·36
South London Company	4,350	1·12	1·92	6·87
South Metropolitan Company	9,800	0·96	1·51	8·19

Full particulars of the power companies' costs are not available; but, in general, both the cost and the average price received per unit are less than shown in the above table.

The smaller profits earned by the companies are noticeable. One of the main reasons is,

that in nearly all the company areas there is a second competing company, with the result that large unnecessary capital and other costs are involved. In the municipal areas there is no competition. A second reason is the large capital sums spent by the companies on pioneering work.

An inexpert study of these figures would lead to many erroneous conclusions. It might be argued, for instance, that a small undertaking can supply at less cost than a large undertaking, and that the former are more profitable than the latter.

The reasons for the large variations in the costs and in the selling prices are to be sought in the existence, or otherwise, of competition, in differences in the price of coal, the number of consumers, their average load and the use made by each consumer of electricity.

In water-power work it is usual to employ the unit of measurement one kilowatt-year, that is to say, 8,000 Board of Trade units developed in one year by one kilowatt. The cost or price of one kilowatt-year is a fair means of comparing one water-power system with another, provided that the length of mains and number of consumers are approximately equal and the load factor over 70 per cent. This unit would not give accurate results, however, if applied to steam or gas driven stations. A combination of the two measurements of power in kilowatts and energy in units gives more accuracy, but even then many qualifying factors must be applied.

The total cost of supplying electricity to a consumer is made up of the following items:—

A. *Power Station Charges.*

1. Capital charges, including interest, reserve, depreciation and sinking funds, say, 10 per cent. on the capital.
2. Fuel and stores.
3. Wages and salaries.
4. Repairs, rates, rents, etc.

B. *Distribution Charges.*

1. Capital charges.
2. Maintenance, rates, wages, salaries, etc.

The total capital charges usually represent about 50 per cent. of the total cost of supplying a consumer with electricity. The power companies with a relatively small number of large consumers show figures rather less than 50 per cent., whereas undertakings supplying many small consumers in large towns often show more than 50 per cent.

It is probably not generally realised that the average cost of connecting a consumer, including the service, meter and proportion of the distribution main, is about £25.

The coal bill represents about 25 per cent. of the total charges to the consumer, and the other charges the remaining 25 per cent.

The incidence of the above charges varies with the class of load supplied, as follows:—

	Per cent.		
Total capital charges . .	from 30	to	60
Coal.	,, 55	to	10
Other working expenses . .	,, 15	to	30

The first figures represent approximately the ratio for undertakings supplying a small number of large consumers with a high load factor, and the latter figures undertakings supplying a large number of small consumers. Of the total, the items that vary in approximate proportion to the output in Board of Trade units consist in an amount represented by the cost of three-quarters of the coal and stores, with a proportion of the repairs and wages, or, say, 25 per cent. of the total cost of the supply. Consequently, if 100 represents the total cost of working a particular undertaking at a load factor of 20 per cent., and if by reason of the consumers using their supply for longer hours they use twice the number of units, the total cost will be increased to 125. Therefore, the average cost per unit will be reduced by 37 per cent.

Having regard to the fact that the distribution capital represents approximately 50 per cent. of the total capital employed, and that the cost of transformation, distribution and maintenance of meters represents some 20 per cent. of the total cost, it follows that no decrease in the price of bulk supply by super-stations or otherwise can possibly result in a very large reduction in price to the ordinary small consumer. The ordinary consumer can effect for himself a reduction in the price per unit of much larger magnitude by making a better use of the supply.

In an ordinary private house, if the units used for lighting are about 300 per annum, the units used for heating and cooking will be about 3,000 per annum. Taking the price for lighting at 6*d.* per unit and the price for heating and cooking 1*d.* per unit, the average price per unit would be 1·4*d.*

The recent high prices of coal and other fuel and the difficulty of obtaining supplies have resulted in a great increase in the use of electricity for heating and cooking, and, no doubt, had the apparatus for its use been readily

obtainable, this increase would have been greater. There has also been a great increase in the use of electricity for power; the load factor has increased, and, in spite of the fact that new plant, when installed, has cost more than 50 per cent. above pre-war prices, that the price of coal, having regard to quality, has doubled, that wages and other expenses have increased two or three times, the electricity supply undertakings have been able to carry on and to make ends meet with a relatively small increase in price generally not exceeding 50 per cent. and with a smaller increase in the average selling price.

The steam turbine, by making possible the use of very large plants of an economy far higher than can be attained by other means having regard to capital cost, revolutionised the means of generating electricity. Had plant remained at pre-war prices, there is no doubt that progress in replacing small stations by large turbine stations would have been rapid. The advance in the cost of plant and mains necessarily must result in delay in effecting a change. I set out in Table II. the cost of power stations of small and large sizes. The figures are exclusive of the cost of land and are nearly twice the figures obtaining before the war. I also show the approximate working expenses; these figures must be taken as typical; local conditions might produce wide variations. The figures show clearly the economy to be gained from the use of large plant.

In Table III. I show the cost of underground and overhead transmission lines, the cost of the latter varying from less than one-half to slightly over one-third that of the former. The figures in the last column show that under the best conditions the cost of transmission for distances exceeding twenty miles is a serious item. It is impossible, in the length of a general paper, to give more than typical figures, but it is clear that the increased cost of plant and mains must mean that the superseding of existing plant will be delayed.

The first overhead electric line under Board of Trade consent was erected at St. Helens in Lancashire. Since that date many miles of overhead lines have been run. Their use reduces the cost, particularly of services to works, collieries, mines, farms, and other scattered loads. For trunk lines carrying large power there is less advantage. The overhead lines are less reliable than underground lines. Lightning and wind may do much damage and alternative routes become advisable, where security of supply is a matter of the first importance. Great improvements are possible in means to increase the distance over which power can be economically trans mitted.

It is not possible to lay down general rules for the supply of electricity. Much nonsense has been talked about the universal use of super-stations, as though it were necessary only to erect a sufficient number to produce an electrical millennium. There is, of course, no question that where a sufficient load can be collected within a moderate distance, accompanied by a site for the power station, with the ample water-supply necessary to the running of a large turbine plant, a station of the largest size should be used. Where there is not adequate water, the super-station is not possible. Again, where there are several suitable sites, and the load is distant from any one site, it will be more economical to use two or more smaller stations rather than to concentrate all the plant on one site and incur the great cost of mains.

One advantage of connecting up power stations over relatively wide areas so that they feed a common system of transmission lines, is that the large amounts of waste heat available in some parts of the country can be made full use of. In districts where there are collieries, coke ovens, rolling mills, and similar plants, there is an immense waste of energy in the form of either steam or gas. Efforts have been made in the past to use some part of this waste heat for the purpose of supplying power for use in the works. The difficulty is that very often the heat is wasted intermittently; at times it is much less than that required in the works, and at other times greatly in excess of that required. Consequently, only a small proportion can be made use of in this way. By converting the whole of the waste heat into electricity feeding into a common network of mains, the whole of the electricity generated can be used. The interesting paper read by Mr. R. P. Sloan at the Newcastle meeting of the British Association in 1916, gave valuable information as to the use made of waste heat in the Newcastle district. Mr. Sloan showed that much had been accomplished by the Associated Companies in the north-east coast area, and there are many other parts of the country where advantage can be taken of this valuable source of energy.

Much has been written about the possibility of using the coal so as to obtain some or all of the by-products. At the present time every

TABLE II.—SHOWING CAPITAL AND WORKING COSTS FOR POWER STATIONS ERECTED AND WORKED AT PRESENT-DAY PRICES FOR MATERIALS AND LABOUR.

Plant Installed. No. of Units.	Plant Installed. Size of Units.	Capital Cost.	Maximum Load.	Capital per Kilowatt of Load.	Load Factor.	Units Generated.	Coal Consumption.	Running Costs. Cost of Coal at 20s. per ton.	Running Costs. Other Works Costs.	Running Costs. 12½ per cent. on Power Station Capital.	Running Costs. Total Costs.	Running Costs. Per Unit generated.
	kw.	£	kw.	£	Per cent.		lb. per Unit gen'td.	£	£	£	£	d.
2	250	28,100	250	112·4	25	547,500	5·0	1,230	1,070	3,500	5,800	2·54
					50	1,095,000	4·75	2,330	1,100	3,500	6,930	1·52
3	500	55,500	1,000	55·5	25	2,190,000	4·5	4,400	2,600	6,900	13,900	1·52
					50	4,380,000	4·25	8,300	2,700	6,900	17,900	0·98
4	1,000	125,650	3,000	41·88	25	6,570,000	3·5	10,250	5,900	15,700	31,850	1·16
					50	13,140,000	3·25	19,000	6,100	15,700	40,800	0·75
5	2,000	240,000	6,000	40·0	25	13,140,000	3·0	17,600	11,500	30,000	59,100	1·08
					50	26,280,000	2·75	32,200	11,800	30,000	74,000	0·68
6	5,000	535,000	20,000	26·75	25	43,800,000	2·5	48,900	21,000	67,000	136,900	0·75
					50	87,600,000	2·3	89,900	21,500	67,000	178,400	0·49
7	10,000	1,100,000	50,000	22·0	25	109,500,000	2·25	110,000	31,500	137,500	279,000	0·61
					50	219,000,000	2·10	205,000	32,500	137,500	375,000	0·41
6	25,000	2,142,000	100,000	21·42	25	219,000,000	2·0	195,500	53,000	268,000	516,500	0·57
					50	438,000,000	1·8	352,000	55,000	268,000	675,000	0·37

The figures in the above table are merely typical. They may be expected to vary somewhat according to the locality and the site. They include estimated figures for buildings, wharfage, sidings, etc., but are exclusive of the cost of land and of providing circulating water.

TABLE III.—SHOWING THE COST OF TRANSMISSION SYSTEMS AT PRESENT-DAY PRICES FOR LABOUR, AND TAKING COPPER AND LEAD AT £100 AND £25 PER TON RESPECTIVELY.

Size of Conductors and pressure.		Useful Capacity in Kilowatts.	Capital Cost per mile run.	Capital Cost per Kilowatt per mile run.	Working Cost. Per mile run.	Working Cost. Per Kilowatt per annum per mile run.
			Underground System.			
□″	Pressure. volts.	Kilowatts.	£	£	10 per cent. on Capital.	£
·075	3,300	320	4,000	12·5	400	1·25
·125	3,000	540	5,000	9·3	500	0·93
·125	11,000	1,800	5,500	3·0	550	0·30
·125	22,000	3,600	6,000	1·7	600	0·17
·125	33,000	5,400	7,000	1·3	700	0·13
			Overhead System.			
□″	Pressure. volts.				12½ per cent. on Capital.	
·075	3,300	320	1,300	4·0	162·5	0·51
·125	3,300	540	1,600	3·0	200	0·37
·125	11,000	1,800	2,600	1·45	325	0·18
·125	22,000	3,600	2,900	0·80	350	0·10
·125	33,000	5,400	3,200	0·6	400	0·08

Two cables and six overhead wires are included in each line to work with three-phase alternate current.

gasworks, by distilling the coal, converts a portion of the fuel into illuminating gas and recovers other portions in the form of coke sulphate of ammonia and tar. Coke ovens, low-temperature distillation plants and the Mond and other similar systems of gas production, convert a portion of the fuel into gas, retaining other portions as coke, ammonia, crude benzol or tar.

The difficulty about all these methods is that either coke or gas must be burnt under boilers when turbines are used, and neither is a very satisfactory boiler fuel, and both coke and coal gas command a large general market at high prices. This method also involves the consumption of about 25 per cent. more fuel owing to the extraction of part of the coal and its consequent loss as a heating agent, and the double heat losses in the producers or retorts in addition to that in the boiler.

If the gas could be used direct, without the agency of the boiler, then a solution of the difficult problem would become nearer. It is a problem calling for the most skilful research on a large scale, and it is to be hoped that the attention now being given to the subject by Sir George Beilby and many others may in due course produce a solution. Much time, however, is likely to elapse before these methods effect any material reduction in the price of electricity. With present methods, about 18 per cent. of the heat energy in fuel can be converted into electricity. Every engineer looks forward to the time when this figure can be improved. There are several promising lines of research open, and with sufficient time, money and skill, success should be achieved.

So often the argument is advanced that State or municipal ownership results in low prices, that it is well to examine the claim so far as it relates to electricity supply. The main arguments advanced are that money can be raised at a lower rate of interest, and that there are no profits. Consequently, the price charged for electricity need not include so large an allowance for capital charges. This theory, in practice, is not found to hold good. In the first instance, before the war, companies were able to raise loans by means of debentures at rates of interest varying from 3½ to 4½ per cent.; municipalities in general paid from 3 to 3½ per cent., or, say, some 1 per cent. less; but under the terms of the loans they were obliged to provide sinking funds to redeem the loans in about twenty-five years, involving a sinking fund of from 3 to 3½ per cent. In place of a sinking fund, the companies usually apply to depreciation and reserve an amount equal to about 2 per cent. of the capital; consequently, so far as the loans are concerned, the total annual payment for money so raised is approximately the same as for municipalities.

The companies also raised considerable sums of money by the issue of preference shares entitled to dividends at the rate of from 4½ to 6 per cent.; the money so raised thus cost, after allowing for depreciation, perhaps one-half of 1 per cent. more than the money raised by the municipalities. Something like one-half of the total capital of the companies has been raised by the issue of ordinary shares, and average dividends have been paid thereon of approximately 4 to 5 per cent.

The matter may be examined by comparing the gross profit earned by the company and municipal undertakings. The figures, extracted from "Garcke's Manual of Electrical Undertakings," are as follows:—

TABLE SHOWING THE AMOUNTS OF CAPITAL EXPENDITURE AND GROSS PROFIT IN CERTAIN COMPANY AND MUNICIPAL-OWNED ELECTRICITY UNDERTAKINGS.

Year.	No. of Undertakings.	Capital Expended.	Gross Profit before providing for Depreciation.	Percentage of Gross Profit to Capital.
		Company Undertakings.		
		£	£	%
1914	98	25,132,662	1,722,396	6·8
1915	95	26,281,952	1,686,389	6·4
1916	93	25,958,683	1,673,552	6·4
1917	111	27,107,746	1,914,634	7·0
		Municipal Undertakings.		
1914	186	45,250,532	3,653,919	8·0
1915	199	49,424,226	3,952,902	8·0
1916	180	49,375,009	3,830,077	7·8
1917	172	49,246,295	4,054,771	8·2

The main reason for the difference in gross profit is that the companies in general supply under more difficult conditions than the municipalities. The latter supply nearly all the large manufacturing towns excepting Newcastle and London, and in the latter there are over all the dense central areas competing companies, and in the county areas of the power companies difficult distribution problems have to be faced.

The whole principle of public electricity supply depends on the fact that a large central plant can supply power with a less consumption of coal than individual small plants, and a vast amount of money is required to carry out the large-scale experiments necessary to increase the amount of power obtained per ton of coal. Some of the electricity supply authorities, both company and municipal, have spent considerable sums in improving boilers and accessory apparatus. Improvements in steam turbines and other plant have been introduced mainly by manufacturers. There is no doubt that had the prices charged to the consumers been increased by even 1 per cent., and had the additional profits been applied to improving methods and apparatus, the cost to-day to the consumer would have been less. Whatever is ultimately decided upon for the future conduct of electricity supply, it is to be hoped that at least the finances of the industry will be arranged so that, whether it be called profit or not, there will be such a margin over and above the cost of production, including the capital charges, as will provide an ample reserve not only for the replacement of plant as it becomes obsolete, but also for the conduct of large-scale experiments, directed to increasing efficiency and improving methods. There is rightly a reluctance to raise money especially for these purposes, and, in fact, it is a most unsound method of finance. The existence of profits and the expenditure of a sufficient sum for the above purposes is the only way to establish the business on a really firm foundation, and is the surest way to provide for the production of electricity at the lowest possible price.

The report of the Electric Power Supply Committee clearly contemplates probably large financial assistance from the State.

I, for one, consider that financial assistance from the State for industry may be, in certain cases, necessary and justifiable, but that such assistance should be rendered only when absolutely necessary, and, so far as possible, regard should be had to ordinary commercial requirements, that is to say, the money should be laid out so as to bring in a proper return. There are many clear instances where State assistance is highly desirable in the interests of the community. For example, the Uganda Railway was a very commendable enterprise for the State to undertake in order to open up a new colony.

State assistance may be properly given in driving roads and building bridges in order to open up new country. In some instances there will be no direct return on the capital, although the effect of carrying out the works may bring an indirect return commensurate with the expenditure. The question to be considered is whether the business of electrical supply can be properly put into this category. There is plenty of experience to guide us. There is already invested in the business nearly £100,000,000.

Experience shows that electrical supply is a stable industry, and although the margin of profit has been small in the past, in the sense that the ordinary shareholders of companies have received an average dividend of only 4 to 5 per cent., the business is one that should offer a safe investment for capital, and in the future there should be no difficulty in raising dividends to 8 or 10 per cent. Had the original Provisional Order companies been granted permanent tenure, there is no reason why they should not be able to raise in the future, as in the past, all the money required for their full development. Again, the power companies raised large sums of money, and after earning very small profits for some years they are gradually improving their position, as the following figures show:—

Year.	No. of Companies.	Capital Expended.	Gross Profit.	Capital.
				Per cent.
1910	6	6,246,322	249,728	4·0
1913	7	7,461,917	374,684	5·0
1917	8	10,495,454	723,640	6·9

They have now established themselves, and there is no reason why they should not become increasingly prosperous commercial undertakings, able to raise through the ordinary channels the money they require for development.

Again, the larger municipal undertakings showed in the year 1917 an average return on the capital expended of 8 per cent., and the figures given in "Garcke's Manual of Electrical Undertakings" for the municipal undertakings as a whole, show that, in addition to meeting

the whole of the interest and sinking fund charges, they were able, in 1917, to set aside for reserve a sum of £414,818 on the total capital sum invested of £49,246,295.

From these figures there does not seem to me to be any strong case for State assistance, so long as the development of electrical supply proceeds along well-trodden lines.

It is, however, undesirable that the undertakings in certain parts of the country, where large towns exist in close proximity to one another, should continue to develop their undertakings solely for each town. There are many districts where a large power-station should be erected in a suitable position to meet the increasing demand, not in one town only, but in several towns, so that the process described earlier in the paper as having been performed by some of the companies should be carried out on a still larger scale for groups of towns including the intervening areas.

Apart from the industrial areas, there are large areas in the country consisting of entirely rural districts with a few small towns. The supply to the whole of these districts from one or more stations, even with overhead mains, is not commercially practicable, as probably for many years no adequate return could be expected. The amount of power used per square mile is exceedingly small and is likely to remain small. Consequently, since the amount of coal used is also small, it is very doubtful, in the present state of the art, whether in these areas any useful purpose could be served by running mains. Development should proceed outwards from the towns. With this object a uniform system should be adopted so that, when eventually the call for power increased in the intermediate districts, the supplies could be linked together so as to form a uniform and complete system. It may be argued also that the saving of coal to be effected by the development of electric supply is of such importance as to warrant the expenditure by the State of large capital sums with little chance of any direct return. The chief saving of coal is made, not so much by changing from a small station to a large one, although this is very considerable, as by changing from an isolated plant to a central electrical supply. The individual plant may use as much as 12 tons of coal per kilowatt per annum, as against 4 tons at a central power station.

Throughout its history electricity has enjoyed no monopoly. When first introduced there were other means for providing light and power in common use. The suppliers of electricity have always been subjected to fierce competition, at first from the gas engine and latterly from suction gas plants, Diesel engines and local steam plants, particularly when steam is required not only for power but also for process work, and heating. Electricity often has been unable to show any direct saving in cost, with the result that the small local plants have continued in operation and new local plants have been put down. Before putting down independent plant, it is to be regretted that consumers often fail to realise that, although the immediate comparison may show some small advantage in its favour, the ultimate advantage is all in favour of the central supply of power, as once the private plant is installed the cost of power cannot be reduced until the plant is finally scrapped at the end of fifteen to twenty years; in fact, as the plant gets older the cost of running it tends to increase. Again, the cost of extending the private plant is always considerable, and very often results either in scrapping the plant and purchasing power from the central station or in making expensive additions in cramped situations. Against this fixed cost, the tendency of the central station is to reduce continually its costs; its load is always growing, necessitating the installation of new plant, which is invariably more economical than the old plant. The skill and attention given to the plant tend to increase as the plant increases in size, resulting in a steady decrease in the cost of production and in a lower price to the consumer. Every new customer of a central station reduces the incidence of the standing charges, and enables the date for erecting new and more economical plant to be advanced. There is no doubt that the most satisfactory method of financing a power undertaking is for most of the consumers to have, at any rate, some direct financial interest in its success. The prices for power should be so fixed as to produce an ample return on the capital, so that sufficient amounts can be set aside to provide for the early scrapping of uneconomical plant, for the adoption of newest methods, for research in the methods of using fuel, and for the payment of, say, 8 to 10 per cent. on the ordinary capital. A company so situated would be able to raise money at the lowest market rate of interest; the fact that its consumers are interested in its prosperity will make them most excellent canvassers, so that the business should increase rapidly; with every increase in business its costs will tend

to decrease, and, consequently, its profits will increase, and should be shared with its consumers before the rate of dividend is increased above, say, 8 per cent., and as the dividend increases the proportion of the profits distributed among the consumers by way of a reduction in price should be increased.

It is probable that in the near future further progress will be made in the electrification of railways. The causes likely to bring this about are the increase in the price of coal, and, with growing trade, the necessity of carrying greater loads, and of increasing the capacity of the present railways. Should these and other factors result in considerable electrification of main lines, a further rapid expansion in the production of electricity will be called for. In my view, these stations should not be put down by the railway companies but by the electric supply authorities, and should form part of their main systems. Any general scheme for improving the supply of electricity in the country must of necessity take into account railway electrification.

In conclusion, it is important to recognise that electrical supply undertakings in this country constitute a business of very great magnitude. The capital invested is given in the report of the Electric Supply Committee approximately as £26,000,000 by companies working under Provisional Orders, £55,000,000 by municipalities, and by the power companies over £10,000,000. These figures are exclusive of plants used for railways, tramways, and private firms. It may fairly be said that these bodies have generally conducted their business with energy and skill, and have built up sound properties. Their accounts show that they have not overcharged the consumer; in fact, rather that the prices have been too low, the margin of profit in both company and municipal undertakings being in general too small to allow of a proper expenditure being made for the purpose of improving methods. A business of this magnitude cannot be radically changed without loss, and the expenditure of much money and much time. The depreciation in the currency and the consequent advance in the prices of plant, wages and material have, from an economic view point, delayed the date for scrapping existing plant, and have made the conservation of capital of the first importance. On the other hand, the increased cost of coal and the necessity for conserving it, are pressing reasons for taking care that future developments make for the maximum of economy. It is clear that the artificial boundaries that have hitherto confined each undertaking to its district should be bridged over. The course of the war tended to delay improvements in the design of plant making for economy, and there is no doubt that in the next four or five years great advance will be made, and it can be confidently anticipated that five years hence the rate of fuel consumption will be reduced, and possibly some steps will be made towards the desirable end of recovering some of the by-products in the coal, the value of which will tend to reduce the cost of providing power. It is almost certain that the plant available to-day will be, from the point of view of economy in coal consumption, obsolete within the next fifteen years. There is the less reason to plunge rashly into huge expenditure far ahead of requirements.

It is tempting to any one who has been closely in touch with the business for many years to lay down the ideal method for conducting it in the future, or at least to discuss in detail the various recommendations that have been put forth for its conduct. I will refrain from such a course—the subject is too large and difficult for any rapid revolutionary treatment. Only harm could result.

One plain fact, I think, emerges, namely, that when Government takes under its wing any enterprise, it should take care that in making laws for its conduct the ordinary principles of business should be observed. The law should enable the business to flourish, instead of making the earning of profit difficult or impossible; it should protect the industry so that ample profit can be earned; large reserves should be encouraged, and increasing profits shared with the customers; thus only can the widest expansion and the lowest prices be attained. If direct State aid is required at all it should be resorted to only when other methods fail. It may be necessary, first, to carry out works which cannot be profitable for years, and, secondly, to ensure against the possible heavy loss that may ensue if a very rapid reduction in the cost of plant occurs in the next few years, causing heavy loss to an undertaking making large extensions at the present time.

The various undertakers, and the associations representing the different branches of the electricity supply industry, are naturally giving the most careful attention to the various reports referred to, and most of them have made public comment thereon. The trend of their comments is to recommend that no drastic step

should be taken until electricity commissioners have been appointed, and that the function of the commissioners should be to bring to bear judicial and skilful consideration to electrical schemes to be submitted to them. Most of these comments press home the desire that the commissioners should not be swayed by political influence.

The commissioners would in fact take the place of Parliamentary committees in hearing and considering schemes put forward by promoters, whether they be combined municipalities, or companies, or new joint boards. After full inquiry into each scheme the commissioners would be in a position to report to Parliament with complete knowledge of the facts. By these means the industry would not be subjected to the great upheaval that must of necessity be caused by the immediate setting up of district boards, and the early purchase of power stations and trunk mains, and the present difficulties could be removed step by step.

Finally, it is of the utmost importance that the present uncertainty should be removed as soon as possible; it is hampering the industry just at a time when confidence is of the greatest importance. Extensions of plant are called for in every direction, and delay will lead to breakdowns and shortage of supply. Naturally, in the present uncertain position, doubtful if their property is to be transferred to rather nebulous district boards yet to be set up, and, if so, at what price, both companies and municipalities hesitate to embark on new expenditure. Any long delay will do far more harm than the district boards can put right for years.

A judicial commission can be quickly appointed; the industry has expressed its desire for such a tribunal. The setting up of district boards is more controversial and such a course is bound to lead to delay. When the commission is set up it should consider the very urgent matter of the position of the Provisional Orders companies, and should make proper arrangements for them to continue their activities under fair conditions; it should also provide means to avoid the wasteful expenditure resulting in unnecessary extensions to uneconomical plants. The industry can then progress, and the difficult question of district boards and State ownership can be properly considered in due course.

DISCUSSION.

MR. JAMES DEVONSHIRE said there was one matter mentioned in the paper which recalled a promotion of many years ago. He referred to the author's reference to the General Power Distributing Company. He thought he was right in saying that that had been the first attempt of any body of promoters in this country to obtain a power Act to supply electrical energy over a very wide area. That was in the year 1898. It had been a desperate fight. He had then been connected with the Thomson-Houston Company, and he had persuaded his directors to embark upon the promotion. He had hinted that it might run into a thousand or two, but when the bill came in, the Act having been lost in the Second House, it was found that the cost amounted to £10,000. It was remarkable to relate that the firm paid the bill and kept the man who had been responsible for its promotion. But they had succeeded in the House of Lords, and he often noticed that when one had a hard nut to crack it was a very good plan to initiate a scheme in the House of Lords. He did not want to say anything against the Commons, but their lordships seemed to be possessed of more judicial minds for new enterprises than the Commons. So it came about that when their Bill reached the House of Commons they had a solid phalanx of opposition from their municipal friends. If they had only been people like the Hackney Borough Council, the Bill would have received the Royal Assent, but unfortunately the people who dealt with the Bill were not so enlightened as some of the modern borough councils were, and by a very small majority the Bill was thrown out on second reading. But the £10,000 had not been wasted, because two years later there was a crop of power Acts, all of which received the Royal Assent, and he thought the promotion in 1898 was the main cause of the setting up of the famous joint committee which had been presided over by Lord Cross, and which had led to the recommendation that electricity should be authorised for distribution over a wide area, and that companies should be set up without the purchase clause of the Act of 1882.

MR. GERALD W. PARTRIDGE stated that the author had mentioned the earlier work done by Dr. Ferranti, and as he (the speaker) had been one of Dr. Ferranti's assistants, it might interest the audience to hear the sort of way in which electricity was supplied in the early days of 1887–8. The supply in those days was from overhead cables run at a pressure of 2,400 volts. From those cables were connected the ordinary house transformers, and so the supply for lighting only was given to consumers. There were no meters in those days, the consumers paid £1 a lamp of 8 candle-power per annum. Mr. Devonshire had referred to desperate times, and he could assure the audience that they were desperate times in those days. The lights were out generally once a week at the very least, and overloading was frequent. Dr. Ferranti, who

was about twenty years in front of everybody else, then designed the now famous Deptford station. He set about erecting that station, and then arose the first and most important question as to how the current was to be brought from there to London. The first idea was to lay the mains overhead a certain part of the way, and the engineers started to erect overhead poles. Of course that was stopped as soon as the land-owners saw what was being done, and the company had to start to make their own cables, cables suitable for running at a pressure of 10,000 volts. Those cables were in actual use to-day with a joint every twenty feet, and were supplying a great portion of the lighting of the London companies' undertaking to the West End. He thought there were about twenty-eight miles of those cables at present running with a pressure of 10,000 volts to earth. The author also pointed out that certain other companies were supplying direct current. In those days there was deadly enmity between the alternating supply companies and the direct supply companies. The engineers and managers never spoke to one another. In fact, at the Institution of Electrical Engineers there was what was called "The high-tension corner," where all the alternating current men used to sit alone. That was the state of things in those days. Nearly every country in the world had practically copied Dr. Ferranti's idea of putting the large super-station outside the town on or near the water in order to generate as cheaply as possible. The author had referred to the proposed super-stations which people were now talking about in such a vague manner. He thought many of them did not appreciate that for every pound of coal burnt 500 lb. of water were required for condensing purposes. At present he knew of no colliery in the country suitable for a super-station where such a large amount of water was likely to be available. Anyhow, the whole question of circulating water was one of very great importance. It had always been a great drawback to supply undertakings that they were unable to store their energy. That had been one of the great advantages of the gas companies. It appeared to him that if use could be made of the large electric heaters, consumers could be induced to store the energy on their premises, by that means the load factor of the system might be improved and such consumers would at least be entitled to a very low rate for their current—he should say very little over the actual cost of the coal. During the war, in certain countries such as Italy and Switzerland, coal had been almost unprocurable, even at prices of from £10 to £12 a ton. At present the Swiss people are very short of coal but have abundant water power, and they have set about making use of large electrical heaters. At the present time he was given to understand that they had no less than forty-seven different types of electric heaters in use or being completed. Those heaters were of two types, one totally enclosed, which would probably be fitted with a thermostat to prevent overheating, and the larger ones were provided with openings communicating within their interior so as to allow of increasing the area of radiation as the temperature falls. It seemed to him that if a large use could be made of those heaters, the load factor of the various supply companies would be greatly improved and far more use would be made of electricity in the place of coal for the heating of buildings. One heard a great deal about the housing of the working-classes at the present time, and he thought wide use of electricity could be made in that direction.

Mr. Leonard L. Robinson remarked that during the war, when the north-east of London was very short of plant, his Council (the Hackney Borough Council), upon his advice, very readily departed from the old and stupid municipal practice of damning everything that a company could do, and joined hands with the North Metropolitan Company so that they could link their stations together and use the plant of the company's two stations and their own to the very best advantage for the production of munitions in the north-east of London. They did so by running a cable from the Council's sub-station in the north of Hackney to a sub-station supplied by the North Metropolitan Company in Stoke Newington, stepping up their end from their pressure of 6,000 volts 3 phase to the company's pressure of 11,000. They used that cable throughout the war to supply a portion of the North Metropolitan Company's area, and they were using it to-day constantly for keeping the loads on their respective works at economical figures—so much that they never now ran their works unless they had a load for a big turbine. The whole of the week-end work was done for them by the North Metropolitan Company. The saving was most striking. Before the linking-up they had been using considerably over 3 lb. of coal per unit, and at the present time they were generating at less than $2\frac{1}{2}$ lb. per unit.

Mr. W. L. Madgen said that one of the most serious difficulties which had been successfully faced by power companies in the past had been the competition of private plants. Owing, however, to various circumstances acting together—the uncertainty regarding legislation affecting industry, which was not only affecting the question of extensions on the part of the power supply undertakers, but was also unsettling the minds of consumers running large works—a considerable number of private plants were now being put in. He believed he was safe in saying that the increase had been very serious, and that of the electrical generating machinery now on order, at least one third were for the purpose of private plants. That was largely due to the manner in which the question of legislation was being handled by the authorities. It was to be hoped that the greatest possible pressure would

be brought to bear upon the authorities concerned to do something quickly so that the industry might not be more seriously handicapped than it had been. Months had gone by since the report of the Board of Trade Committee on the subject, and everybody was entirely in the dark as to what the intentions of the Government really were. He ventured to say that if the electrical supply industry was going to be administered by hybrid district boards of an analogous character to the Water Board of London, and initiative and enterprise and push emasculated out of it, a still further tendency to put in private plants would result.

Mr. P. D. Tuckett asked if the author would explain the table which he exhibited on the wall, and which he thought helped to demonstrate very forcibly the important point which the author had brought out, viz., the fact that capital charges represented so large a proportion of the total cost that any revolutionary cheapening of supply, such as the super-station fetish had led the public to expect, was out of the question. With regard to Mr. Magden's remarks on private plants, his own experience was that, although the power companies had always been in competition with private plants, the tendency now was for almost all manufacturers to prefer not to put in private plants if the power company was in a position and willing to give them a supply. Of course, in the present legislative uncertainty as to the future of the industry the companies hesitated to expend large sums of money in providing facilities for manufacturers where they had not the plant or facilities available. Otherwise, he thought the tendency was increasingly in favour of the central station as against the manufacturer putting in his own private plant.

Mr. C. A. Baker, M.I.E.E., observed that the author had referred to the difficulties which had arisen in connection with legislation. A recent meeting had been held by the Society (March 19th) when Lord Moulton had been in the chair. That meeting had dealt largely with the distribution of gas, and judging by the Chairman's remarks on the paper it was very evident that Lord Moulton was a gas advocate, and so strong a gas advocate that one could hardly imagine that he had altogether changed his coat during the last fifteen or twenty years. In his speech, Lord Moulton stated that "he had appeared for all the electric companies when the first electric Bill came before Parliament." As the people who promoted the first electric Bill before Parliament had been unfortunate enough to ask a gas advocate to represent them, perhaps it threw some light on the condition of the laws which had been obtained for the organisation of electrical industries! Then another speaker at that meeting made a comparison between gas cooking and electric cooking. The remarks were on page 349 of the *Journal*, and he thought they were misleading to people who might read them, "that cooking done by 100 units of electricity used in a modern cooker was equivalent to the work done by 1,000 cubic feet of gas in an old-fashioned gas cooker." He, the speaker, had some figures in his hand which were obtained from one of the County Council's cookery centres, which were fair and unbiased. The figures referred to cooking two similar dinners by gas and by electricity. Each dinner consisted of 4 lb. 1 oz. of beef, boiled potatoes, boiled greens, and an apple pie. The cost to cook the dinner by gas was 1·26*d*. When cooked by electricity it was 1·4*d*., but the joint cooked by gas was reduced in weight by 12½ oz. and that cooked by electricity by only 7½ oz. Therefore the total cost of gas cooking was 9·86*d*. and the total cost of the electrical cooking 6·55*d*. On the basis of the respective meter registrations 39 units of electricity were equivalent to 1,000 cubic feet of gas, or, extending the figures, 100 units of electricity were equal to about 2,580 cubic feet of gas used for cooking purposes. It was important that electric cooking should at least have fair play. It gave a very fair load factor, and from every point of view it should be encouraged.

Mr. G. L. Addenbrooke stated that as one of the old pioneers of the industry he had been alarmed at the attitude which the public took towards the whole question of electricity. There seemed to be a sort of idea about the country at present that if the Government took over the electric supply, every farmer within five miles of a town could have electric lighting throughout his farm and buildings, and motors and everything else, and that every cottage in a remote district could have the same. That was not the case. People were told of transmissions abroad where circumstances were entirely dissimilar, and they imagined that the same could be done in this country. If very large super-power stations were to be erected, and it was necessary, as it appeared to be at the present time, to go long distances to get condensing water for them, one was necessarily bound down to those places which in many respects would not be at all suitable otherwise; that was to say, they would be a long way from the centre, which would mean very costly transmission lines being located in those places, railway lines and a large traffic over those lines, and altogether they would be quite out of their proper places should future developments make it possible to generate current without that extraordinary expenditure of water. It did seem to him that the condensing question had arisen entirely over the peculiar properties of turbines. An enormous amount of mental power all over the world was being devoted to the generation of energy, and to its application on the most economical principles, and it seemed to him almost impossible that great advances would not be made in that respect, which would probably do away with that very great necessity of using immense quantities of water for condensing. Sup-

posing such a change occurred even in twenty years, all those enormously costly stations, railway lines and everything would be in the wrong places permanently, and if several millions were going to be spent on each of those stations, the whole future would be handicapped. There was no doubt that the industry was a very complicated one, because it was bound down by transmission, and to scrap more or less or use as a secondary thing all that had been done in the last twenty-five years, and to make more or less a fresh start, would occasion great disorganisation and delay, besides which it was pretty clear that, even supposing such a Bill were passed for setting up those stations, the negotiations, the plans and different arrangements must take two or three years before very much could be done. Sub-stations took a long time to build, and, consequently, the whole industry would be in a state of uncertainty for the next five or six years during the time when reconstruction was very important, and when it was desirable that the country should pull itself together as quickly as possible. He could not but hope that more sane and conservative counsels would prevail in high quarters in the future than had been the case in the past.

Mr. F. W. Jennings said that one point which had not been brought out very clearly was the advantage of using private plants where there was a big demand for steam for process or heating work. In many cases an engine could be run non-condensing, even against a considerable back pressure, and the whole of the steam used for process work. He was familiar with those works where private plants had been put in after being disconnected from a central supply and the coal bill had not been altered at all. Consequently, the only cost of electricity had been the capital expenditure, the interest on capital, and depreciation. If that was developed a little more, some of the small stations might be used to a great deal better advantage than they were at present. There was no getting away from the fact that the maximum efficiency of a condensing station was 20 per cent., and the efficiency, if one used the latent heat in the exhaust steam, might be something like 60 per cent.

The Chairman (Mr. Alan A. Campbell Swinton) observed that if one looked back to the beginning of electricity supply, the surprising thing was that the supply was as good as it was, taking into account all the difficulties which had had to be contended with, mostly difficulties due to political considerations. If the industry had had a perfectly free hand, and if there had been no politics brought into the matter, he was sure the electricity supply would have been in a vastly superior position to what it was to-day. Hundreds of thousands of pounds must have been spent in fighting Bills and in squabbling over political questions in connection with electrical supply, which money ought to have been spent upon the machinery necessary for giving a supply, instead of in lawyers' fees, witnesses' fees, and so on. The same applied to the wasted work and energy which ought to have been put into the technical and business side of the matter. He only hoped that things were not going to be made worse than they were at present. If the Government would only appoint a technical board of technical people to attend to the matter, and would take it out of the hands of the politicians who had their own eggs to fry, everybody would be thankful.

Mr. John Somerville Highfield, in reply, said, with regard to Mr. Tuckett's request for an explanation of the table exhibited on the wall, it was not very easy to give a simple explanation, but he would call attention to two or three points. He would take the station capable of carrying a load of 20,000 kilowatts. For that plant the capital charges amounted to £67,000, and the working costs to £111,000. That showed the very large proportion which the capital charges bore to the total cost of production. The next point to be noted was that the capital cost of a station capable of carrying a 50,000 kilowatt load was £22 per kilowatt as compared with £40 per kilowatt for a station capable of carrying a 6,000 kilowatt load, a saving of £18 per kilowatt in the capital cost. Turning to Table III., showing the cost of mains, the least expensive underground main worked out at £1·3 per kilowatt per mile, so that in a run of twenty miles the saving in capital cost was more than wiped out. The distance with overhead mains could be extended to thirty miles. He had read Sir Dugald Clerk's paper referred to by Mr. Baker. It was a most entertaining paper, the trend of it being to show that if the production and sale of gas were developed instead of electricity, a greater saving in coal would result. Theoretically this might be the case, but the use of small gas engines for power was not convenient. With regard to heating and cooking, the fact remained that electricity was used more and more every day for these purposes. The theoretical thermal efficiency might be less than for gas stoves, but the extreme efficiency of electricity in use and the ease with which it was turned on and off probably more than made up for any increased thermal deficiency in its production. The difficulties that would arise if new authorities were set up to purchase existing power stations and transmission mains had hardly, he thought, been realised. One difficulty was as follows. There were a great number of small power stations in the country—he meant stations of 5,000 to 10,000 kilowatt capacity. Those stations had been put up at a time when plant was cheap. They were not nearly so efficient as the plant one could put up to-day, but there they were. If anybody came along and said to the owner of such a plant, "I desire to buy this plant," the owner would say, "Well, it is quite true that before the war my plant was out of date and old in

the sense that more economical plant can now be bought," but he (the speaker) thought the owner would also say, "In order to replace this plant with new plant I now have to lay out at least twice as much money as I spent on this plant; consequently, if you want my plant, which is a good plant, you must not pay me the capital cost in my books, but twice that cost." The effect was going to be this: the consumers at the moment who were supplied from that plant were enjoying the result of the cheap plant bought before the war, when values were different from what they were at present, and they could continue to enjoy those advantages because the supplier of electricity was not out to double his profits, and as long as he owned the old plant he could run it and keep his prices as they were; but if that plant were transferred at double what it cost to a new authority altogether, the new authority would have to raise the prices to the consumer proportionately. Therefore the chances of the consumer enjoying cheaper electricity from such a transfer were not remote—they were impossible. Several speakers had referred to the difficulty of supplying very large turbine plants with sufficient condensing water. The so-called super-station would require a fair-sized river for the purpose. It was essential to obtain this very ample water-supply, and consequently super-stations must be erected near large rivers or estuaries. The difficulty suggested a possible use for old battleships. He saw no reason why a power-station should not be set afloat. The difficulty of condensing water would at once disappear, the difficulty of coaling would be greatly reduced, and ash-handling and matters of that sort would become perfectly simple.

On the motion of the CHAIRMAN a hearty vote of thanks was accorded Mr. Highfield for his interesting paper.

GENERAL NOTES.

THE SOCIETY OF ENGINEERS.—In compliance with a suggestion by the Ministry of Labour (Appointments Department), the library and reading-room of the Society of Engineers (Incorporated), 17, Victoria Street, Westminster, S.W. (1), have been placed at the disposal of officers at present looking out for appointments in the engineering and allied professions. All such officers are also invited to attend the ordinary meetings of the Society, particulars of which may be obtained on application to the Secretary.

BRITISH WAR MEDAL DESIGN.—From fifty-one designs for the British War Medal to be issued in commemoration of the great war, the works of the following London artists have been judged to be the three best in order of merit: (1) Mr. William McMillan, (2) Mr. Charles Wheeler, (3) Mr. C. L. G. Doman. They have been awarded monetary prizes—£500, £150, and £75 respectively. Mr. McMillan's design, which is to be adopted for the reverse of the medal, represents St. George on horseback trampling on the Prussian shield.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 19...Metals, Institute of, Caxton Hall, Westminster, S.W., 8 p.m. Professor F. Soddy, "Radioactivity."

Brewing, Institute of (London Section), Imperial Hotel, Russell-square, W.C., 6 p.m. Mr. W. A. Riley, "Steam and Power Plant for Breweries."

Geographical Society, Kensington-gore, W., 5 p.m. Captain W. B. R. King, "The Use of Geology in War."

TUESDAY, MAY 20...Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Dr. F. M. Perkin and Mr. T. C. Palmer, "The Chemist and Engineer in relation to the Petroleum Industry."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "British Ethnology—the People of Ireland." (Lecture IV.)

British Women's Patriotic Leagues, 92, Victoria-street, S.W., 3 p.m. Miss H. Normanton, "How we gained our Rights and Liberties as British Citizens."

Anthropological Institute, 50, Great Russell-street, W.C., 8.15 p.m. Captain A. M. Hocart, "The Early Fijians."

WEDNESDAY, MAY 21...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Sir F. T. Piggott, "The Principles of Japanese [illegible]."

Meteorological Society, 70, Victoria-str[illegible]., 5 p.m. 1. Capt. C. J. P. Cave and Mr. J. S. Dines, "Further Measurements on the Rate of Ascent of Pilot Balloons." 2. Messrs. J. E. Clark and H. B. Adames, "Report on the Phenological Observations for 1918."

Geological Society, Burlington House, W., 5.30 p.m.

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5 p.m. Mrs. M. L. Woods, "The Youth of Wordsworth."

THURSDAY, MAY 22...Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor F. Keeble, "Intensive Cultivation." (Lecture II.)

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Dr. S. Chapman, "Electrical Phenomena occurring in High Atmospheric Levels."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Professor P. G. H. Boswell, "The Geology of Aggregates and Sands."

FRIDAY, MAY 23...Royal Institution, Albemarle-street, W., 5.30 p.m. Sir A. Mackenzie, "Hubert Hastings Parry: His Work and Place among British Composers."

SATURDAY, MAY 24...Linnean Society, Burlington House, W., 3 p.m. (Anniversary Meeting.)

Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. Wells, "Caesar as a General." (Lecture II.)

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—May 16, 1919.

No. 3470. MAY 23, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,470. VOL. LXVII.

FRIDAY, MAY 23, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MAY 26th, at 4.30 p.m. (Extra Meeting.) CAPTAIN FRANK E. D. ACLAND, M.Inst.C.E., M.I.Mech.E., "A New Prime Mover of High Efficiency and British Origin." The Hon. SIR CHARLES ALGERNON PARSONS, K.C.B., LL.D., D.Sc., F.R.S., will preside.

TUESDAY, MAY 27th, at 4.30 p.m. (Colonial Section.) LIEUT.-COLONEL THE HON. SIR JOHN McCALL, M.D., LL.D., Agent-General for Tasmania, "Science and Industry in Australia."

WEDNESDAY, MAY 28th, at 4.30 p.m. (Ordinary Meeting.) HARRY J. POWELL, "Glass-making before and during the War." SIR RICHARD TETLEY GLAZEBROOK, C.B., Sc.D., F.R.S., Director of the National Physical Laboratory, will preside.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 21st, 1919; Mr. JOHN SLATER, F.R.I.B.A., Member of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Dolland, William George Balicourt, London.

Ellis, Owen William, M.Sc., Assoc.M.Inst.C.E., London.

Farmer, Professor John Bretland, M.A., D.Sc., F.R.S., London.

Flanagan, William Henry, Buxton, Derbyshire.

Girod, Paul, Ugine, Savoie, France.

Holland, Sir Thomas Henry, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Simla, India.

Hurst, James Edgar, Manchester.

Lennox, John, Motherwell, Scotland.

The following candidates were balloted for and duly elected Fellows of the Society:—

Acland, Frank E. D., M.Inst.C.E., M.Inst.M.E., London.

Cash, Henry James, A.M.I.E.E., London.

Hoole, William George, Lake Macquarie, New South Wales, Australia.

Robotham, Francis Edward, London.

A paper on "The Principles of Japanese Design" was read by SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 14th, 1919; MAJOR-GENERAL SIR PHILIP NASH, K.C.M.G., C.B., in the chair.

THE CHAIRMAN, in introducing the author, said there was no more important subject at the present time than railway transport in the United Kingdom. Transportation as a whole had to play a vital part in the process of restoration and reconstruction, and railway transport was the most important section of transportation in this country. The author was well qualified to discuss the subject, as he had made a name for himself in India, where he had held a most important charge on one of the big railway undertakings in that country, since when he had shown by the papers he had read in other places, and by his publications, that he was a deep student of the subject, and not only a student, but also an advocate of bold measures when they were necessary. He thought before the author had finished his paper he would have shown the audience that something in the nature of important measures had to be taken.

The paper read was—

RAILWAY TRANSPORT IN THE UNITED KINGDOM.

By H. Kelway-Bamber, M.V.O.

Introduction.

At a time when the ownership, control, management and working of the railways of the United Kingdom are matters of special national interest and importance, it may be useful:—

(a) To pass briefly in review, on broad lines, the working results of all the railways of Great Britain and Ireland, treated as one system, for the ten years immediately preceding the outbreak of war.

(b) To estimate the prosective railway traffic of the near future.

(c) To consider how the requirements of this traffic may best be met, with special reference to the efficiency of rolling-stock under existing load gauge restrictions; and

(d) To indicate the effect on British railways of through communication with Europe and other continents, following upon the construction of the proposed Channel Tunnel.

Working Results, 1904 to 1913.

The population of the United Kingdom at the commencement of the year 1904 was, approximately, 42,370,000; at the end of 1913 it was 46,035,000—an increase of 3·665 millions, or 8·65 per cent.

The total length of railway track mileage on the same dates was 50,624 and 55,405 respectively—an increase of 4,781 miles, or 9·44 per cent.

The total paid-up capital (including nominal additions, etc.) was £1,235·53 millions on January 1st, 1904, and £1,334·01 millions on December 31st, 1913, the increase thus amounting to £98·48 millions, or 8 per cent.

The biennial increase in total paid-up capital and in open line extension during the same period was:—

Paid-up Capital and Open Mileage.

Year ended Dec. 31st.	Total paid-up capital, including nominal additions, etc. (millions).	Increase (millions).	Percentage of increase.	Total track mileage.	Increase.	Percentage of increase.
	£	£		Miles.	Miles.	
1903	1,235·53	Basis	—	50,624	Basis	—
1905	1,272·60	37·07	3·0	52,322	1,698	3·3
1907	1,294·07	21·47	1·7	53,158	836	1·6
1909	1,314·41	20·34	1·6	53,972	814	1·5
1911	1,324,02	9·61	0·7	54,570	598	1·1
1913	1,334·01	9·99	0·8	55,405	835	1·5

The detailed developments of total track mileage were as follows:—

Length of Open Mileage.

Year ended December 31st.	Route (mileage).	Route track (mileage).	Siding track (mileage).	Total track (mileage).	Proportion of siding to route track (mileage).
					Per cent.
1903	22,435	37,255	13,369	50,624	36
1905	22,870	38,431	13,891	52,322	36
1907	23,112	39,013	14,145	53,158	36
1909	23,280	39,622	14,350	53,972	36
1911	23,425	39,916	14,660	54,570	36
1913	23,691	40,656	14,749	55,405	36
Increase in 10 years	1,256	3,401	1,380	4,781	40·57
Percentage of increase	5·6	9·1	10·4	9·4	

The average total capital cost per route, route track, and total track mile, and the gross receipts per route mile per annum for the decade were:—

Capital Cost per Route, Route Track, and Total Track Mile.

Year ended December 31st.	Average capital cost per Route mile.	Route track mile.	Total track mile (including sidings).	Average gross receipts per route mile per annum.
	£	£	£	£
1903	55,071	33,164	24,406	4,594
1905	55,690	33,120	24,360	4,601
1907	55,991	33,134	24,345	4,854
1909	56,461	33,174	24,354	4,754
1911	56,521	33,173	24,263	5,007
1913	56,317	32,812	24,077	5,218
Increase or decrease in ten years	+1,246	−352	−329	+624
Percentage of increase or decrease	+2·26	−1·06	−1·35	+13·58

Total Gross Receipts, Working Expenses, Net Receipts.

The total gross receipts from all sources rose from £110·89 millions in 1903 to £139·45 millions for the year 1913—an increase of £28·56 millions, or 25·76 per cent., the proportion of gross receipts to total paid-up capital increasing steadily from 8·91 per cent. in 1903, to 10·45 per cent. in 1913, the improvement for the decade amounting to 17·28 per cent.

The total working expenses amounted in 1903 to £68·56 millions, and in 1913 to

£87·32 millions—an increase of £18·76 millions, or 27·36 per cent.

The net receipts meanwhile rose from £42·33 millions in 1903 to £52·13 millions in 1913—an increase of £9·8 millions, or 22·91 per cent.

The average return of net receipts on total paid-up capital (including nominal additions, etc.) gradually increased from 3·43 per cent. in 1903, to 3·64 per cent. in 1913, or by 6·12 per cent.

The development in the increase of gross receipts, working expenses, and net earnings, etc., are shown biennially below.

Year ended December 31st.	Gross receipts from all sources (millions).	Working expenses (millions).	Net receipts (millions).	Proportion of working expenses to gross receipts.
	£	£	£	Per cent.
1903 . . .	110·89	68·56	42·33	62
1905 . . .	113·53	70·06	43·47	62
1907 . . .	121·55	76·61	44·94	63
1909 . . .	120·17	75·04	45·14	62
1911 . . .	127·20	78·62	48·58	62
1913 . . .	139·45	87·32	52·13	62·62
Increase in 10 years	28·56	18·76	9·80	
Percentage of increase	25·76	27·36	22·91	

The relation of the percentage of the foregoing increases is approximately as shown below:—

Gross receipts . . .	= 1·00
Working expenses . .	= 1·06
Net receipts	= 0·89

From the foregoing it will be noted that during the decade 1904–1913:—

(*a*) The population of the United Kingdom increased by 8·65 per cent.

(*b*) The total length of open track mileage (including sidings) increased by 9·44 per cent.

(*c*) The total paid-up capital (including nominal additions, etc.) increased by 8·0 per cent.

(*d*) Gross receipts from all sources increased by 25·76 per cent.

(*e*) Working expenses increased by 27·36 per cent.

(*f*) Net receipts increased by 22·91 per cent.

(*g*) The average total capital cost per route and total track mile decreased by about 1·0 per cent.

(*h*) Average gross receipts per route mile improved by 13·58 per cent.

(*j*) The proportion of gross receipts to total paid-up capital increased, by over 17·8 per cent., to 10·45 per cent.

(*k*) The proportion of working expenses to gross receipts ranged from 62·0 to 63·0 per cent.

(*l*) The average return of net receipts on total paid-up capital (including nominal additions, etc.) for 1913, compared with 1903, improved by 6·12 per cent.

Principal Sources of Revenue.

The total gross receipts from all sources for the year 1913 amounted, as has already been shown, to £139·45 millions.

The contributions from the principal sources of revenue, and their proportion to the total gross receipts from all sources for the year 1913, were as follows:—

Source of revenue.	Total receipts for 1913 (millions).	Proportion to total.	Proportion to total.
	£	Per cent.	Per cent.
Goods traffic .	66·64	47·78	88·64
Coaching traffic	56·98	40·86	
Miscellaneous .	15·83	11·36	11·36
Total . . .	139·45	100·00	100·00

The total gross receipts from coaching and goods traffic, representing 88·64 per cent. of the total revenue from all sources, amounted in 1913 to £123·62 millions compared with £103·08 millions in 1903—an increase of £20·54 millions, or 29·63 per cent.

Of the total traffic receipts for 1913, goods contributed £66·64 millions, or 54 per cent., and coaching £56·98 millions, or 46 per cent., and these proportions remained practically constant throughout the decade.

The actual goods receipts in 1903 amounted to £55·11 millions, and in 1913 to £66·64 millions—an increase of £11·53 millions, or 21 per cent.

Coaching receipts in 1903 were £47·97 millions, and in 1913, £56·98 millions—an increase of £9·01 millions, or 18·93 per cent.

Miscellaneous receipts derived from steamboat traffic, harbours, canals, hotels, rents, etc., increased from £7·81 millions in 1903 to £15·83 millions in 1913—an improvement of £8·02 millions, or 102·70 per cent., due principally to a revised system of accounting.

The development and increase in revenue

from the principal sources is shown biennially below.

Year ended December 31st.	Total goods receipts (millions).	Total coaching receipts (millions).	Total traffic receipts (millions).	Total miscellaneous receipts (millions).	Total receipts from all sources (millions).
	£	£	£	£	£
1903 . .	55·11	47·97	103·08	7·81	110·89
1905 . .	56·41	48·72	105·13	8·40	113·53
1907 . .	61·20	50·97	112·17	9·37	121·54
1909 . .	59·48	51·20	110·68	9·49	120·17
1911 . .	63·28	53·95	117·20	9·96	127·19
1913 . .	66·64	56·98	123·62	15·83	183·45
Increase in 10 years	11·53	9·01	20·54	8·02	28·56
Percentage of increase	21	18·93	29·63	102·70	25·76

Receipts from Goods Traffic.

Of the total receipts from goods traffic during the ten years 1904–1913, about 50 per cent. was derived from the carriage of general merchandise and 48 per cent. from minerals, and these proportions varied but little throughout the decade.

Receipts from general merchandise traffic in 1903 amounted to £28·28 millions, and in 1913 to £33·00 millions—an increase of £4·72 millions, or 16·69 per cent.

Receipts from mineral traffic amounted in 1903 to £25·35 millions and in 1913 to £31·97 millions—an increase of £6·62, or 26·12 per cent.

The increase in general merchandise, mineral, and total goods traffic receipts is shown below.

Year ended December 31st.	Receipts from general merchandise (millions).	Receipts from mineral traffic (millions).	Receipts from miscellaneous traffic (millions).	Total goods traffic receipts (millions).
	£	£	£	£
1903 . .	28·28	25·35	1·48	55·11
1905 . .	28·75	26·27	1·39	56·41
1907 . .	30·29	29·41	1·50	61·20
1909 . .	29·58	28·40	1·50	59·48
1911 . .	32·07	29·46	1·75	62·28
1913 . .	33·00	31·97	1·67	66·64
Increase in 10 years	4·72	6·62	0·19	11·53
Percentage of increase	16·69	26·12	1·3	20·92

Note.—From the above statement it will be observed that receipts from goods and mineral traffic, as a whole, increased at an average rate of about 2 per cent. per annum.

To the total increase of £11·53 millions, in goods traffic receipts during the decade, general merchandise contributed £4·72 millions, or about 40 per cent., and mineral traffic £6·62 millions, or 58·3 per cent.; the proportion of mineral traffic to total traffic receipts (coaching and goods) being about 26 per cent. through the decade.

Summarising the increase, etc., in revenue from the principal sources during the years 1904–1913, we have:—

	Per cent.
(*a*) Increase in total gross receipts from traffic	29·63
(*b*) Proportion of goods receipts to total traffic receipts	54·00
(*c*) Proportion of coaching receipts to total traffic receipts	46·00
(*d*) Increase in goods receipts	21·00
(*e*) Increase in coaching receipts . .	18·93
(*f*) Proportion of general merchandise to total goods receipts	50·00
(*g*) Proportion of mineral to total goods receipts	48·00
(*h*) Increase in general merchandise receipts	16·69
(*j*) Increase in mineral traffic receipts .	26·12
(*k*) Proportion of increase from general merchandise	40·00
(*l*) Proportion of increase from mineral traffic	58·30
(*m*) Proportion of mineral to total traffic receipts (goods and coaching) . .	26·00

Train Miles and Receipts per Train Mile.

Coaching Traffic.

The distance covered by coaching trains in 1903 was 232·39 million, and 1913, 273·49 million miles—an increase of 41·10 millions, or 17·68 per cent.

Total coaching receipts during the same period rose from £47·97 millions in 1903 to £56·98 millions in 1913—an increase of £9·01 millions, or 18·78 per cent.

The average total coaching receipts per train mile amounted in 1903 to £·2064, and in 1913 to £·2083—an increase of £·0019, or less than 1 per cent.

The coaching train mileage and receipts for the decade 1904–1913 are shown biennially below.

Year ended December 31st.	Total coaching train mileage (millions).	Total coaching receipts (millions).	Average coaching receipts per train mile.	
		£	£	d.
1903 . . .	232·29	47·97	·2064	49·53
1905 . . .	244·39	48·72	·1994	47·85
1907 . . .	262·55	50·97	·1941	46·58
1909 . . .	263·81	51·20	·1942	46·61
1911 . . .	270·27	53·95	·1996	47·90
1913 . . .	273·49	56·98	·2083	49·99
Increase in 10 years	41·10	9·01	·0019	0·46
Percentage of increase	17·68	18·78	0·99	0·99

It will be noted that while the total coaching train miles and coaching receipts both increased by an average of about 18 per cent., the receipts per train mile increased by less than 1 per cent., and this notwithstanding the fact that on the whole, the scale of charges for fares remained practically constant throughout the decade.

Goods, Mineral and Mixed Traffic.

The distance covered by goods, mineral and mixed trains in 1903 was 161·63 million miles, and in 1913, 161·68 millions—an increase of 0·05 millions, or 0·03 per cent.

The total goods and mineral traffic receipts rose from £55·11 millions in 1903 to £66·64 in 1913—an increase of £11·53, or 20·92 per cent.

The average receipts per goods and mineral train mile for 1903 amounted to £0·341, and for 1913 to £0·412—an increase of £0·71, or 20·82 per cent.

The goods and mixed train mileage, receipts and earnings are shown biennially below.

Year.	Total goods, mineral and mixed train mileage (millions).	Total goods, mineral and mixed traffic receipts (millions).	Average goods, mineral, and mixed traffic receipts per train mile.	
		£	£	d.
1903 . . .	161·63	55·11	·341	81·84
1905 . . .	156·33	56·41	·361	86·64
1907 . . .	165·82	61·20	·369	88·56
1909 . . .	158·43	59·48	·383	91·92
1911 . . .	158·36	63·28	·399	95 76
1913 . . .	161·68	66·64	·412	98·88
Increase in 10 years	0·05	11·53	·071	17·04
Percentage of increase	0·03	20·92	20·82	20·82

From the above statement it will be seen that the receipts for goods, mineral, and mixed train traffic increased during the decade by nearly 21 per cent., and that with practically no increase in the train mileage.

Summarising the increase in train mileage and receipts per train mile during the decade we have—

	Per cent.
(*a*) Increase in coaching train miles .	17·68
(*b*) Increase in coaching traffic receipts.	18·78
(*c*) Increase in average receipts per coaching train mile	0·99
(*d*) Increase in goods, mineral, and mixed train miles	0·03
(*e*) Increase in goods, mineral, and mixed traffic receipts	20·92
(*f*) Increase in average receipts per goods, mineral, and mixed train mile	20·82

Number of Passengers Carried and Receipts.

Excluding season-ticket holders, the number of passengers carried rose from 1195·26 millions in 1903 to 1,454·76 millions in 1913—an increase of 259·5 millions, or 21·74 per cent.

The total coaching receipts rose from £47·97 millions in 1903 to £56·98 millions in 1913—an increase of £9·01 millions, or 18·8 per cent.

The average coaching receipts per 100 passengers (excluding season-ticket holders) fell from £4·013 in 1903 to £3·092 in 1913, a decrease of £0·921, or just under 30 per cent.; the decrease being due to the great increase in the number of short journeys on London Tube, District, and other suburban railways.

Weight of Goods Lifted and Receipts.

Prior to the year 1913 the weight of goods, coal, and minerals originating, *i.e.* loaded into wagons on each railway system, was not shown in the returns of the railway companies of the United Kingdom, but for that year the equivalent and the total weight carried by all companies were as follows:—

Goods traffic.	Total carried (millions).	Originating on the systems of the respective companies (millions).	Percentage originating.
	Tons.	Tons.	
General merchandise	121·36	72·91	60·08
Minerals—			
Coal, coke, etc.	345·11	226·94	65·76 } 67·0
Other minerals	101·73	72·19	70·67 }

If these percentages be applied to the general merchandise and mineral traffic of the ten years under consideration, the actual weight of these materials originating on individual systems and loaded into wagons biennially is as follows:—

Year ended December 31st.	General merchandise. Total carried (millions).	General merchandise. Total originating on the systems of respective companies (millions).	Minerals. Total carried (millions).	Minerals. Total originating on the systems of respective companies (millions).	Total weight loaded into wagons (millions).
	Tons.	Tons.	Tons.	Tons.	Tons.
1903 . . .	100·08	60·05	343·69	230·27	290·32
1905 . . .	103·06	61·84	358·08	239·91	301·75
1907 . . .	108·29	64·97	407·60	273·09	338·06
1909 . . .	104·55	62·73	395·36	264·89	327·62
1911 . . .	113·76	68·26	409·81	274·56	342·82
1913 . . .	121·36	72·82	446·84	299·38	372·20
Increase in 10 years	21·28	12·77	103·15	69·11	81·88
Percentage of increase	21·26	21·26	30·00	30·00	28·21

From the foregoing statement it will be seen that the weight of minerals loaded annually is more than four times that of general merchandise, and that the increase in the weight of minerals loaded annually, compared with general merchandise, was approximately in the proportion of 1·5 : 1.

On the basis of the actual weight loaded into wagons on originating lines, the receipts per ton of general merchandise and minerals carried during the decade were as follows:—

Year ended December 31st.	General merchandise. Weight carried (millions).	General merchandise. Receipts (millions).	General merchandise. Average receipts per ton.	Minerals. Weight carried (millions).	Minerals. Receipts (millions).	Minerals. Average receipts per ton.	Total. Weight carried (millions).	Total. Receipts (millions).	Total. Average receipts per ton.
	Tons.	£	£	Tons.	£	£	Tons.	£	£
1903	60·05	28·28	0·471	230·27	25·35	0·110	290·32	53·63	0·185
1905	61·84	28·75	0·465	239·91	26·27	0·109	301·75	55·02	0·182
1907	64·97	30·29	0·466	273·09	29·41	0·108	338·06	59·70	0·177
1909	62·73	29·58	0·471	264·89	28·40	0·108	327·62	57·98	0·177
1911	68·26	32·07	0·473	274·56	29·74	0·108	342·82	61·71	0·180
1913	72·82	32·99*	0·453*	299·38	32·00	0·107	372·20	64·99	0·175*
Increase in 10 years	12·77	4·71	—	69·11	6·65	—	81·88	11·36	—
Percentage of increase	21·26	16·67	—	30·00	26·23	—	28·21	21·18	—

* Excludes expenses for collection and delivery.

From the figures in the foregoing statement it will be noted that the gross receipts per ton from the carriage of general merchandise and minerals remained practically constant through the decade, averaging:—

Traffic.	Average receipts per ton.		
	£	d.	s. d.
General merchandise .	0·469	112·56	9 4·56
Minerals	0·108	25·99	2 1·99
Merchandise and minerals	0·180	43·20	3 7·20

The average receipts per ton for the year 1913 were:—

	s. d.	s. d.
General merchandise . .	9 ·06	
Coal, coke, and patent fuel	2 ·2	2 1·65
Other minerals	2 6·1	

Summarising the increase, etc., in passenger and goods traffic and in receipts for the decade, we have:—

	Per cent.
(a) Increase in the number of passengers carried (excluding season ticket-holders)	21·74
(b) Increase in coaching receipts . .	18·80
(c) Decrease in coaching receipts per passenger	30·00
(d) Increase in weight of general merchandise carried.	21·26
(e) Increase in receipts from general merchandise carried	16·67
(f) Increase in weight of minerals carried	30·00
(g) Increase in receipts for minerals carried	26·23

Earnings of Rolling-stock.

The work done by locomotives, carriages, and wagons in transporting passengers and goods,

as reflected in gross receipts, affords, in the absence of ton-mile statistics, an important means of judging whether the business of transportation, so far as rolling-stock is concerned, is being efficiently conducted.

Receipts per Locomotive.

The total traffic receipts for the year 1903 amounted to £103·08 millions, and for 1913 to £123·62 millions, an increase of £20·54 millions, or approximately 20 per cent.

The total number of locomotives in 1903 was 22,385, and in 1913, 24,728—an increase of 2,343, or 10·4 per cent.

The average receipts per locomotive in 1903 amounted to £4,604, and in 1913 to £5,000—an increase of £396, or 8·6 per cent.

The average receipts per locomotive for the decade are shown biennially below.

Year ended December 31st.	Total traffic receipts (millions).	Number of Locomotives.	Average receipts per locomotive.
	£		£
1903 . . .	103·08	22,385	4,604
1905 . . .	105·13	22,346	4,704
1907 . . .	112·16	22,514	4,982
1909 . . .	110·68	22,778	4,859
1911 . . .	117·24	22,849	5,125
1913 . . .	123·62	24,728	5,000
Increase in 10 years	20·54	2,343	396
Percentage of increase	20·00	10·4	8·6

Receipts per Coaching Vehicle.

The total coaching receipts for the year 1903 amounted to £47·97 millions, and in 1913 to £56·98 millions—an increase of £9·01 millions, or 18·79 per cent.

The total number of coaching vehicles in 1903 was 70,291, and in 1913, 76,614—an increase of 6,323, or 9 per cent.

The average receipts per coaching vehicle amounted in 1903 to £682, and in 1913 to £743—an increase of £61, or 9 per cent.

The average receipts per coaching vehicle for the decade 1904–1913 are shown biennially below.

Year ended December 31st.	Total coaching receipts (millions).	Number of coaching vehicles.	Average receipts per vehicle.
	£		£
1903 . . .	47·97	70,291	682
1905 . . .	48·72	70,909	659
1907 . . .	50·97	72,694	701
1909 . . .	51·20	72,942	702
1911 . . .	53·95	73,074	738
1913 . . .	56·98	76,619	743
Increase in 10 years	9·01	6,323	61
Percentage of increase	18·79	9·0	9·0

Receipts from Goods Vehicles.

The total receipts from goods, mineral, and mixed traffic in 1903 amounted to £55·11 millions, and in 1913 to £66·64—an increase of £11·54 millions, or 20·94 per cent.

Information as to the number of privately-owned wagons for the year 1903 not being available, a comparison with 1913 has not been practicable.

The total number of railway and privately-owned vehicles at the end of the year 1913 is understood to have been approximately 1,500,000, at which figure the average earnings per wagon engaged in goods and mineral traffic worked out at $\frac{£66,640,000}{1,500,000} = £44·23$ per annum, or just over 2*s.* 5*d.* per day.

It has been shown above that the average receipts per ton of goods (general merchandise and minerals) conveyed during the decade 1904–1913 was 3*s.* 7·2*d.*, so that the average work done per wagon is equivalent to the carriage of 0·67 tons, or a little less than 13·5 cwts. per day for a year of 365 days.

Number of Round Trips.

It is estimated that approximately 900,000 privately-owned and railway companies' wagons were engaged during 1913 in the coal and mineral traffic of this country, and assuming that 5 per cent. were undergoing or waiting repair or renewal, we have 855,000 wagons available for traffic purposes. On this basis each wagon of 10 tons average capacity would be loaded:—

$$\frac{30,000,000 \text{ loads}}{855,000 \text{ wagons}} = \left\{ \begin{array}{l} \text{35 times in the year, or} \\ \text{about once in 10 days.} \end{array} \right.$$

Mineral Wagon Earnings.

The average receipts per ton of coal, coke and patent fuel moved in 1913 was 2*s.* 0·2*d.*, and 2*s.* 6·1*d.* per ton of other minerals; the overall average of receipts was, therefore, 25·65*d.*, at which rate the earnings per wagon for the year amounted to $\frac{35 \times 10 \times 25·65}{240} = £37·41$ gross, or 46·76 per cent. of the pre-war average capital cost (£80) per vehicle. The total gross earnings of the 855,000 wagons for the year would thus be 855,000 × 37·41 = £31,985,000, which practically agrees with the figure, £31,972,000, shown in the published railway returns for 1913, viz.:—

Receipts from mineral train traffic—

Coal, coke and patent fuel .	£22,909,000
Other minerals	9,063,000
Total . . .	£31,972,000

Summarising the information given in the preceding paragraph, the receipts, etc., per locomotive, carriage and wagon, were:—

	£
(a) Average receipts per locomotive in 1913	5,000
(b) Average receipts per coaching vehicle in 1913	743
(c) Average receipts per wagon in 1913	44·23
	Per cent.
(d) Increase in average receipts per locomotive (1904–1913) . . .	8·6
(e) Increase in average receipts per coaching vehicle (1904–1913) . .	9·0
(f) Increase in average receipts per wagon (1904–1913) .	Information not available.

WORKING EXPENSES.

The total working expenses for the year 1913 amounted to £87·32 millions, or 62·62 per cent. of the total gross earnings from all sources.

£78·874 millions, or 90·3 per cent. of the total expenditure, was incurred in the working of the railways, and the balance on steam boats, docks, hotels, etc.

Of the £78·874 millions direct railway expenditure, the principal charges and their proportions were:—

	Millions £	Per cent.
Traffic expenses	24,180	30·66
Locomotive running expenses	18,166	23·03
Maintenance and Renewals—		
Way and works	12,526	15·88
Locomotives	6,305	8·00
Carriages	3,771	4·78
Wagons	3,748	4·75
General	2,792	3·54
Others	7,386	9·36
Total . .	78,874	100·00

NET RECEIPTS.

The net income for the year 1913, as has already been stated, amounted to £52·13 millions—an increase of £9·8 millions, or 22·91 per cent. over that for the year 1903, and yielded an average return of 3·64 per cent. of the total paid-up capital, including nominal additions.

This amount, together with £1·137 millions brought forward from account at December 31st, 1913, made a total net income of £53,268,000, from which appropriations were proposed as follows:—

PROPOSED APPROPRIATION.

	£
Fixed charges—	
Interest on loans	361,000
,, ,, debenture stock . .	11,448,000
Miscellaneous	4,055,000
Appropriation to reserve and other special purposes	1,301,000
Dividend on guaranteed and preference stocks	17,239,000
Dividend on ordinary stock . . .	17,705,000
Total	52,109,000
Balance carried forward to 1914 account	1,159,000

The interest and dividend shown above do not include payments in respect of the capital of the companies included in Section B of the Railway Returns for 1913.

PRE- AND POST-WAR RAILWAY WORKING.

Summarising the financial working results of the railways of the United Kingdom, treated as one system, at the close of the year 1913 we have:—

FINANCIAL POSITION AT END OF 1913.

		Millions.
Total paid-up capital	=	£1,334·01
Total receipts from all sources .	=	£139·45
		Per cent.
Proportion of ditto to total capital	=	10·45
		Millions.
Working expenses	=	£87·32
		Per cent.
Proportion of ditto to total receipts	=	62·62
		Millions.
Total net receipts	=	£52·13
		Per cent.
Proportion to total paid-up capital — Including nominal additions . . .		3·64
Proportion to total paid-up capital — Excluding nominal additions . . .		4·27

With a permanent addition of 80 per cent. to the pre-war rate of working charges, and with capital expenditure and gross earnings increasing at the same average rate as before the war, the financial position for the year 1920 should be:—

FINANCIAL POSITION AT THE END OF 1920.

	Millions.
Total paid-up capital	£1,426·0
Total receipts from all sources . .	143·0
	Per cent.
Proportion of ditto to total capital .	10·03
	Millions.
Working expenses	£160·0
	Per cent.
Proportion of ditto to total receipts.	112
	Millions.
Debit balance, including 4 per cent. interest on total paid-up capital .	£74·0

The pre- and post-war (1920–1950) financial

positions of British railways are compared graphically in Fig. 1 and statistically below :—

PRE- AND POST-WAR FINANCIAL POSITIONS.

Year ended December 31st.	1913 (millions).	1920 (millions).	1930 (millions).	1940 (millions).	1950 (millions).
	£	£	£	£	£
Total paid-up capital	1,334·01	1,426·0	1,534·0	1,642·0	1,750·0
,, receipts from all sources	139·45	143·0	162·0	181·0	200·0
,, working expenses	87·32	160·0	180·0	202·0	223·0
,, net receipts	52·13	− 74·0	− 79·0	− 86·0	− 93
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Proportion of total receipts to total paid-up capital	10·45	10·03	10·56	11·02	11·43
Proportion of working expenses to total receipts	62·62	111·00	111·00	111·00	111·00
Proportion of net receipts or debit balance to total paid-up capital (including nominal additions)	3·64	− 5·19	− 5·14	− 5·29	− 5·32

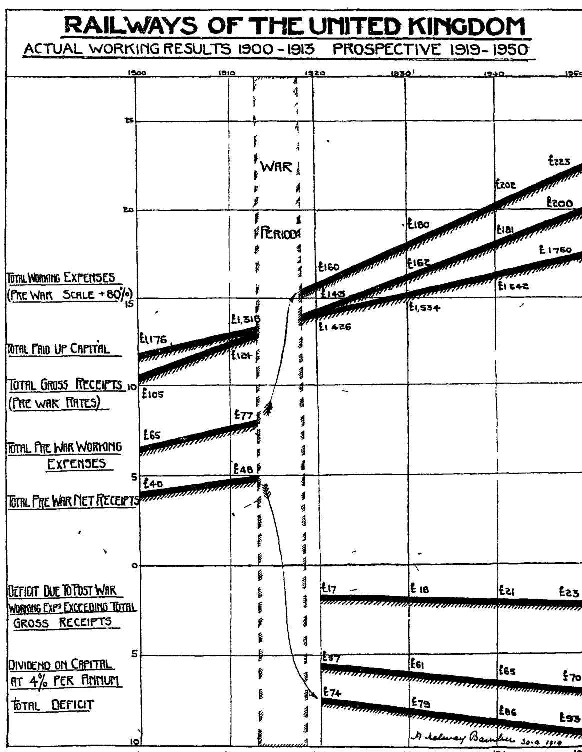
SUGGESTIONS FOR DEALING WITH FUTURE TRAFFIC.

Having now reviewed as fully as time permitted the development, working results, and the financial position of the railways of the United Kingdom up to commencement of the great war, forecasted their probable future development over a period of thirty years, and having estimated the amount of the annual deficit due to the higher cost of working, we may now proceed to consider how the position, which is very serious, may best be met.

The prospective annual deficit estimated at £74 millions in 1920, increasing to £93 millions in 1950, amounts, as will be seen from the following statement, to approximately 50 per cent. of the total gross earnings from all sources.

ESTIMATED FINANCIAL DEFICIT.

Year ended Dec. 31st.	Estimated total gross receipts from all sources (millions).	Estimated debit balance (millions).	Proportion of debit balance to total gross receipts.
	£	£	Per cent.
1920	143	74	51·75
1930	162	79	48·76
1940	181	86	47·51
1950	200	93	46·50



ALL TOTAL FIGURES ARE IN MILLIONS

FIG. 1.

RESTORATION OF FINANCIAL POSITION.

A 50 per cent. increase on pre-war rates, applied alike to coaching and goods traffic as a whole, would therefore immediately restore the situation and yield such an average interest (4 per cent.) on paid-up capital as would encourage the capitalist, and provide for future developments.

But there are fortunately at hand other means

of recovering the situation, the more important of which are:—

(*a*) Permanent unification of railway working, control and management.

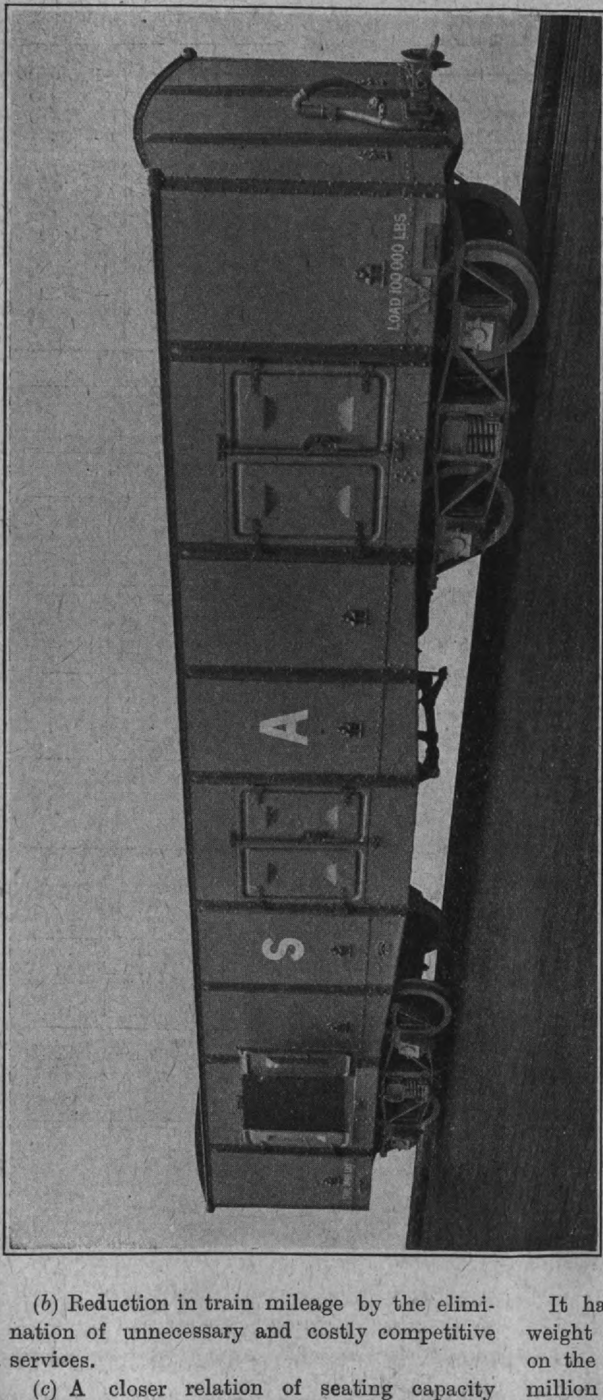


FIG. 2.—SOUTH AFRICAN RAILWAYS. 45-TON BOGIE HIGH-SIDED COAL WAGON.

(*b*) Reduction in train mileage by the elimination of unnecessary and costly competitive services.

(*c*) A closer relation of seating capacity hauled to the traffic offering.

(*d*) A reduction in goods, and especially in mineral train mileage, by the use of high capacity bogie wagons.

(*e*) A speedier discharge and release of wagons, especially of those engaged in the carriage of minerals, rendered possible in the latter case by the use of self-discharging vehicles.

(*f*) A more effective use of locomotive power by improving the relation of paying load to gross weight.

Unification of control should do much to ensure reduction in train mileage, etc.

It has already been shown that the average coaching receipts per passenger train mile had not advanced during the decade; it would therefore appear that there is considerable scope for improvement in this direction.

The average gross receipts per coaching vehicle certainly improved during the decade by about 1 per cent. per annum, but this was probably due more to the effect of well filled trains on tube and suburban lines than to long distance traffic.

Conditions governing the carriage of general merchandise in this country do not favour heavy loads, but there is surely room for improving the cubic capacity of covered wagons used for such traffic.

The possibilities for improving the load-carrying capacity of mineral wagons are, however, great, and in the author's opinion afford the principal means of reducing working expenditure.

INFLUENCE OF HIGH-CAPACITY WAGONS.

It has been shown above that of a total weight of 392 million tons loaded into wagons on the railways of this country in 1913, 299 million tons, or over 76 per cent., consisted of minerals.

At an average of 10 tons per wagon this represents 29,900,000 loads and the handling, on the round trip, of about 60,000,000 vehicles.

On the 3 ft.-6 in. gauge railways of the Union of South Africa, coal is carried in all-steel bogie wagons of 45 tons capacity, types of which are shown in Figs. 2 and 3 respectively.

Had such wagons been universally used for the carriage of coal in this country during 1913, the number to be loaded compared with 10-ton vehicles would have been as shown below:—

Year.	Approximate total weight of coal moved (millions).	Carrying capacity of wagon.	Number of wagon loads (millions).
	Tons.	Tons.	
1913	300	10	30·00
		45	6·67

Year.	Reduction in the number of vehicles loaded (millions).	Percentage of reduction.
1913	Basis	Basis
	23·33	77·77

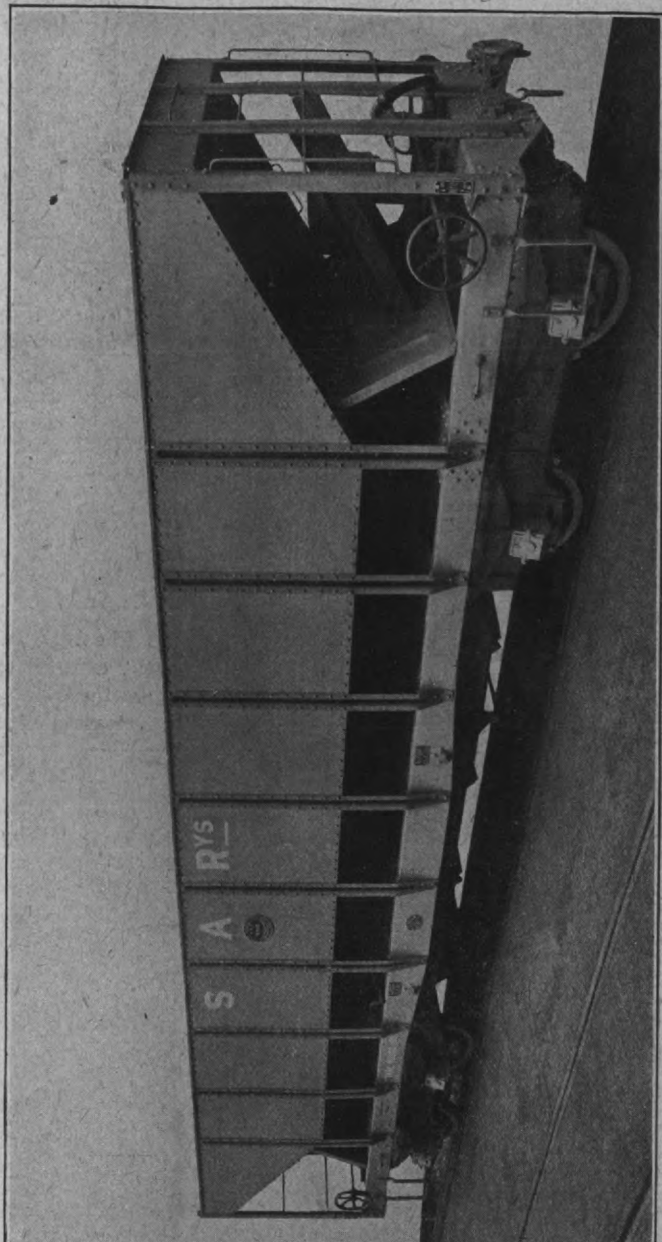


Fig. 3.—South African Railways. 45-ton Self-Discharging Bogie Coal Wagon.

If 12-ton wagons are to become the future standard for mineral traffic in this country, as recently suggested, then fifteen years hence, with a traffic of, say, 450 million tons, the relation of 12- to 45-ton wagons will be as follows:—

Year.	Total weight to be moved (millions).	Carrying capacity of wagon.	Number of wagon loads (millions).	Reduction in the number of vehicles to be loaded (millions).	Percentage of reduction.
	Tons.	Tons.			
1950	450	12	37·5	Basis	Basis
		45	10·0	27·5	73·33

It has been shown above that mineral wagons in this country made an average of 35 round trips per annum, *i.e.* were loaded about once in 10 days.

The already greatly increased and still increasing cost of labour will soon necessitate the use of self-discharging wagons such as those shown in Fig. 4.

The prompt discharge and release of such wagons should enable the average number of loadings to be increased to at least 50, and assuming the universal adoption of 45-ton vehicles, the number required to carry 560 million tons of coal and minerals in 1950 would (Fig. 5) be—

capacity, or about one-seventh the number; and in 1930 with a mineral traffic of 560 million tons—

$$\frac{560 \text{ millions}}{50 \times 45} = 248{,}900 \text{ wagons compared with}$$

$$\frac{560 \text{ millions}}{35 \times 12} = \begin{cases}1{,}866{,}700 \text{ wagons of 12 tons'} \\ \text{capacity, or about } \tfrac{1}{7} \text{ the number.}\end{cases}$$

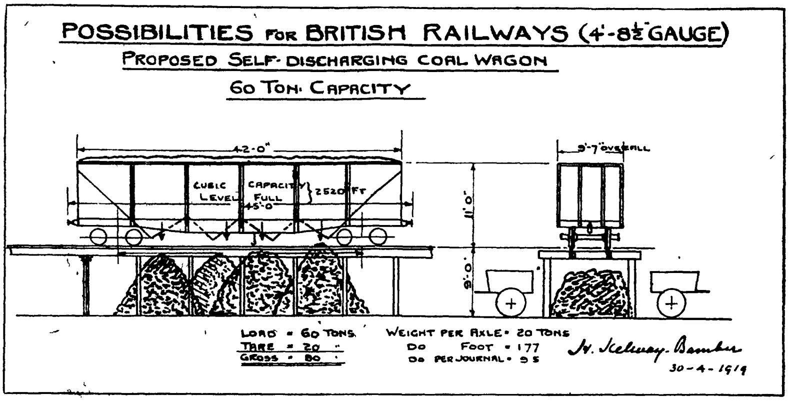


FIG. 4.

$$\frac{560 \text{ millions}}{50 \times 45} = 248{,}900 \text{ wagons, compared with}$$

$$\frac{560 \text{ millions}}{35 \times 12} = 1{,}866{,}700 \text{ wagons of 12 tons'}$$

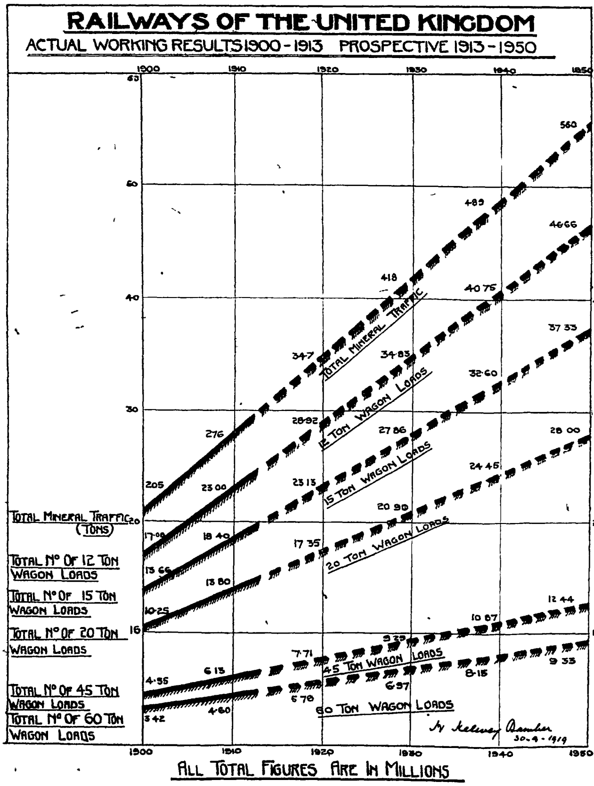


FIG. 5.

The importance of these facts in their relation to the reduction in future capital expenditure, and the enhanced powers of handling a greatly increased traffic, with proportionately decreased traffic charges, are manifest.

Their immediate bearing will perhaps be more fully appreciated by a comparison of present-day British mineral train practice with the possibilities indicated, possibilities involving no drastic changes in road bed, main line track, buildings or plant, but a modification only of colliery loading facilities, and of the provision of suitable unloading arrangements at coal-receiving depôts, etc.

COMPARISON OF A BRITISH RAILWAY COAL TRAIN OF ABOUT 1,300 TONS GROSS WEIGHT BEHIND THE ENGINE TENDERS.

For a gross train weight of about 1,300 tons the improvement in favour of a train of twenty-one 45-ton, compared with eighty 10-ton wagons, will be:—

Weight of coal in 45-ton wagons	945 tons.
Weight of coal in 10-ton wagons	800 ,,
Increase in 45-ton wagons	145 ,,

		Per cent.
Proportion of increase in paying load		18·12

	45-ton wagons.	10-ton wagons.
No. of wagons in train	21	80
Weight of train—		
Coal	945 tons	800 tons.
Wagon	378 ,,	480 ,,
Total	1,323 tons	1,280 tons.

Percentage of paying load to gross weight of train:—

	Per cent.	Per cent.
Loaded	71·43	62·5
Loaded and empty	55·5	45·45

Conversely, if locomotive power be proportionately increased by double heading or other means, and full use be made of the length of existing sidings, then a train composed of thirty-four 45-ton wagons could be stabled in the same siding accommodation as one of eighty 10-ton wagons, the improvement on existing practice would then be:—

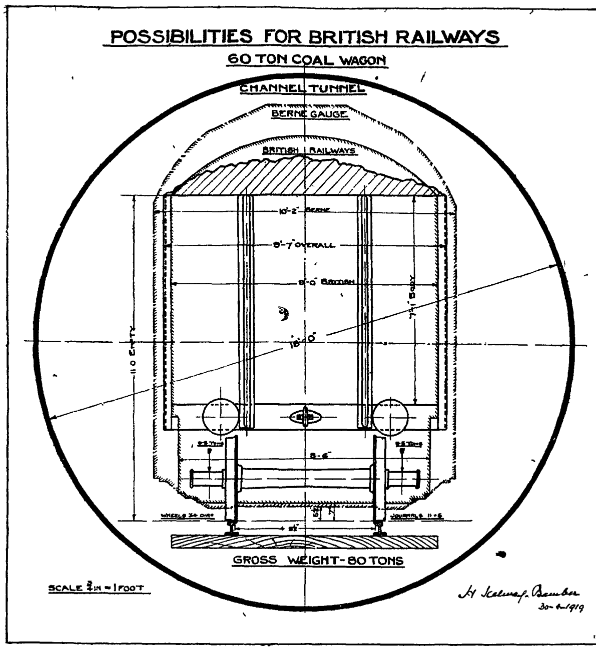


FIG. 6.

No. of 45-ton wagons in the train		34
Weight of coal in train	34×45 =	1,530 tons.
Do. in existing practice	80×10 =	800 ,,
Increase in weight of coal carried in 45-ton wagons		730 tons.
		Per cent.
Proportion of increase in paying load		90

Weight of train	coal	1,530 tons.
	wagons	612 ,,
Total gross weight		2,142 ,,
Length over eighty 10-ton wagons		1,440 ft.
,, thirty-four 45-ton wagons		1,440 ,,
Difference		Nil.

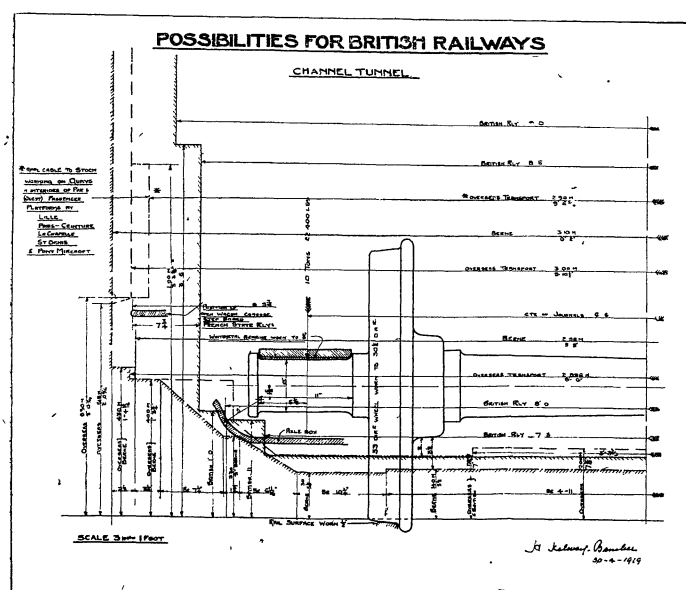


FIG. 7.

It is not suggested that revolutionary changes should be made, but that, as renewals of existing rolling-stock become necessary, high-capacity bogie vehicles with attendant advantages should replace low-capacity four-wheeled wagons whose work is done.

The life of British railway wooden wagons may be taken at from twenty-five to thirty years, and, assuming 900,000 four-wheeled wagons to be at present employed in mineral traffic, at least 30,000 must be replaced annually, their equivalent in "all-steel" 45-ton bogie wagons being about 6,000.

Load Gauges.

Had the British railway load gauge (Fig. 6) been as ample as the European Continental Berne conference gauge, mineral wagons of 60 tons' capacity, or 25 per cent. greater than 45-ton vehicles, might have been standard; the provision of such a load gauge from all the railways of this country would, however, to-day involve very heavy expenditure on structural and other alterations.

The extent to which Continental rolling-stock exceeds the British Railway Clearing House standard load gauge, so far as platforms are concerned, is shown at Fig. 7, and it is obvious that if a through service of trains between London and the Continent is to be established, a new line of railway from the Channel to London must be constructed, or the necessary modifications effected in the existing system.

Conclusion.

The welfare of a country largely depends upon the provision of a cheap and efficient system of transport, and the author has endeavoured to show how, in his opinion, this can best be effected.

We are at the parting of the ways, and on decisions now made will depend not only the future practical and financial success of British railways, but also in a large measure the commercial prosperity of the United Kingdom.

DISCUSSION.

The Chairman (Major-General Sir Philip Nash, K.C.M.G., C.B.), in opening the discussion, said he desired to raise three points. He thought that, in the diagrams which the author had shown, and in which he had reviewed the working results for twenty years, and the prospective working results for a further thirty years, he had assumed that the earning capacity of the British railways, as a whole, had been increasing at a normal rate during the period of the war. That was not the case. Moreover, when the author assumed that British railways were going to increase in the future at the normal rate, it had to be borne in mind that during the war no development had taken place on British railways. There had been practically no capital expenditure on development; and they started with arrears of maintenance, which did not put them in the best form for increasing their earnings. The second point was with regard to statistics. The author's whole paper was a careful marshalling of whatever statistics he had been able to obtain, and the putting of them in diagram form. The author had shown in that way very graphically the gap which existed to-day between earnings and working expenses: in fact, the gap really represented the fact that revenue and expenses were no longer reasonably equated in British railways as a whole. They had lost the equilibrium, and it was in the national interests that steps should be taken to restore that equilibrium. The author had shown that it might be necessary to raise revenue by means of increased rates, but on the other hand he had shown that something was possible—and he (the speaker) thought a considerable amount was possible—by economies in working expenses. If those economies in working expenses were to be obtained the first change which had to take place was to have a proper system of statistics based on a common ground, that was to say, they should be common for all; because in statistics, unless one system was compared with another or one portion of a railway with another, much of the value of criticism was lost. Statistics not only enabled the management of a railway to watch results and were invaluable in that respect, but also much good could be done by extending the statistics for the information of the workers themselves. Simple statistics showing working results would do a lot to interest workers in the national problem of restoring equilibrium. He, personally, had some experience of a good system of statistics in Indian railways, and he knew their value when comparing one undertaking with another. He had also recently had a unique experience in statistics, as, when he was Director-General of Transportation on the Western Front, he had depended upon statistics in order to exercise the economy which was necessary in men and material, and also to gain information on which to base a prudent provision for future requirements, which was a very difficult thing under war conditions. His last point was in connection with larger carrying-capacity wagons and possible economies therefrom. He left it to others who were better acquainted with conditions in England, conditions of trade and so on, to deal with the objections and the difficulties in the introduction of larger-capacity wagons. He knew they existed, but he wanted to bring out one aspect which seemed to him very important in connection with larger carrying-capacity wagons and the loading gauge. The author had briefly mentioned the fact that British wagons could run on the Continent, but the Continental type of wagons, if they were built up to their gauge, could not run in England. This country had to-day physical rail connection with the Continent in train ferries, which were at present working military traffic only. It was perfectly certain that development would not be far distant in the matter of physical rail connection with the Continent, and, whether it was by tunnel or by an extended use of ferries or, as some people advocated, by a bridge, it was certain to come. What would be the position of this country then? He ventured to think that the matter had to be considered from the national point of view. When this country got physical rail connection with the Continent, its position would be that its wagons could all run on the Continent, and Continental wagons would not come back in exchange. What was the posi-

tion on the Continent? He happened to know it well, because the shortage of wagons on the Continent had been one of the most difficult questions during the last three years, in dealing with the military requirements there from the railway point of view. France before the war had an open mileage of about 30,000 miles, and on that mileage she had only 400,000 wagons—wagons of about 13 to 14 tons average capacity—which was far less than most people thought. Italy had about 11,000 or 12,000 miles of railways, and had only 100,000 wagons, of about 15 tons capacity. Those figures showed how badly provided the Continent was with stock. In addition to that, the Continental stock was also in a bad condition. It had been absolutely hammered during the war, and anybody who had an eye for such things would see that it was going to take a good many years before the present Continental stock was brought into an efficient working condition. Therefore, he maintained that if we got physical rail connection with the Continent, and sea freights kept high, it would force traffic on to the Continental rail-borne routes. If there was a big traffic passing in that way it meant that British railways had to provide the stock. Was that going to suit us? It seemed to him, after hearing the author's advocacy of higher carrying-capacity wagons, that, instead of putting our money—he was speaking from a national point of view—into the wagon business to provide wagons to be hired on the Continent, it would pay us better to put our money into improving our own loading gauge, and get the advantage of the exchange of wagons with the Continent, and also improve our own carrying capacity. He thought that was a very important point. He knew from his experience on the Continent that it would exactly suit continental conditions if, for a good many years to come, the railways there could count on a good supply of wagons from this country.

MR. H. N. GRESLEY said he would like to mention the point of increasing the load gauge in this country and standardising the load gauge. That, in his opinion, was one of the points which should have first consideration. It was perfectly useless standardising wagons or locomotives until the gauges themselves were standardised—not only the size of the gauge, but also the roads and bridges to take the heaviest loads.

MR. H. ALDRICH said that, if his memory served him correctly, about eight years ago a paper had been delivered before the Society, which in his opinion solved the problem of the railway trouble. The author on that occasion had laid before the audience a system of removing goods in a container —he was only speaking of general merchandise—so that, instead of the trucks being shunted, the load would be removed from the trucks. He was referring to what was known as the Gattie system, and he would like to know from the author if he considered that that was the solution of the present disastrous state of our railway system.

MR. ROY HORNIMAN said he had attended that afternoon full of hope, because the author had claimed to deal with railway affairs in the United Kingdom, but it seemed to him (the speaker) that he had dealt with a very small part of the business. It was quite impossible to talk of reforms in the railway system of the United Kingdom unless one envisaged the shipping difficulty and the cartage difficulty in their relation to the railway difficulty. It did not seem to him that such proposals as the author had put before the meeting that afternoon were going to solve the difficulty. What was the difficulty so far as this country was concerned? He did not accept what had been said in the House the previous night as to the deficit being £60,000,000. He believed it to be £100,000,000, and he did not believe it was going to stop there. In this country a ton of woollen goods could be carried from London to Bradford at a cost of 8*d*., which included the maintenance of the track and of the locomotive. Such figures as that had been before the country for ten years. They had been sent to the Board of Trade and all the railway managers; they had been guaranteed by the highest actuary in the Kingdom, and nobody had ever stood up to dispute them. As he said, a ton of woollen goods could be carried from London to Bradford for 8*d*., but the railway would send in a bill for £2 17*s*. 6*d*. Allowing 5*s*. for cartage, that left a balance of £2 11*s*. 10*d*., which went in terminal and overhead charges. Therefore, from the point of view of finance, what was the difficulty? The answer was the terminal difficulty, because it was at once proved that it was the terminal difficulty which cost the money. What was the terminal difficulty? Of the terminal expenses—and again the figure had not been disputed—75 per cent. went in shunting. Could shunting be done away with? He maintained it could, as did every eminent engineer. Therefore he thought, from the point of view of expense, the matter was a very much more simple one than people were inclined to admit. He had listened with the greatest pleasure to the frankness with which the author spoke on the question of ton-miles. That had puzzled all the Continental and all the other railways of the world. It had even puzzled the Chinese, who also furnished ton-miles. He agreed with the author that ton-miles were the only reliable basis for railway statistics, and he desired to know why they were not supplied. He only hoped the author would be as earnest and as pertinacious in asking the Board of Trade why they did not supply ton-miles as he had been in elucidating the mass of statistics which he had brought before the meeting that afternoon.

MR. A. W. GATTIE said the statement had often been made that workmen generally were opposed to the introduction of machinery which was going

to rob them of a job. That was not quite true. Workmen were not always opposed to the introduction of machinery. It entirely depended upon the circumstances. The workman was just as sensible as anybody else. He knew very well that man was an implement-using animal, and that if it were not for our implements, tools or machines, we should all be starving to-day. The real point was that the workman desired to have his share in the benefits bestowed by machinery, and where he had not appreciated the introduction of machinery had been in those cases where he had not had that share in the benefit bestowed by the inventor on the community which he should have had. In that connection he might mention that he had given a lecture some time ago at Reading before the National Union of Railwaymen. At the end of the meeting the following resolution had been carried unanimously: "That this meeting of the Reading No. 1 Branch of the National Union of Railwaymen records its opinion that Mr. Basil Peto's charge against railway administration made in the House of Commons on the occasion of the second reading of the Railway Rates (No. 2) Bill, on January 30th, 1913, urgently calls for explanation, and the meeting respectfully suggests that the Prime Minister will immediately institute a judicial inquiry into the whole subject of railway administration, without any limitation as to terms of reference. That the inquiry shall be in no way associated with the Board of Trade or any official thereof, but that it shall be presided over by a commission of His Majesty's judges with full powers to call and examine witnesses on oath, and to discover and use all documents." He thought that resolution would show that railway workmen took a very sensible view of the whole matter. It appeared to him that the best thing to do with regard to railway machinery was to make a railway wagon in two pieces instead of in one. At a lecture which he had given to the South-Eastern and Chatham Railway shortly before the war, he had drawn the attention of that railway company to the fact that where they used a vehicle divided into two parts, that was to say, with an under-carriage and a detachable container, they had succeeded in getting eighty-six times the efficiency of the other wagons in use. He had recommended that system to many big commercial firms some years ago, who immediately adopted it and who had never regretted doing so. That method had given in some instances a difference of 86 per cent. Supposing that, instead of having the present method of taking a train from Liverpool to London, wagons were fitted with detachable containers and hoisting gear at Liverpool and also at London, the company would be able to run a train exclusively used for that route three times the journey in a day, that was, 600 miles. That would give on the ten-ton wagon, supposing they had a 3·4 load, 2,000 ton-miles average work done by a railway wagon on that particular route. That total, as compared with the fourteen and a half ton-miles now accomplished by railway wagons, was rather a remarkable increase.

Mr. F. W. Marillier said one point which he had noticed was that of the flexibility of the bogie wagon over the 10-ton wagon. Speaking for the Great Western Rail way, they did not find that they suffered from that trouble which so many of the freighters' wagons suffered from, namely, hot boxes. The Great Western Railway now had a system by which they lined their bearings with white metal, and they practically had no such things as hot boxes. With regard to using a larger wagon, they found the trouble was in having the through route with a larger wagon, in this country. He believed that the traffic department would state that the most suitable wagon in the country, until all the different stages of the collieries and so forth were altered, was the 10-ton wagon. He agreed with the author that if a larger wagon could be used it would be a great advantage to the country.

Mr. Elias Ford remarked that he had been engaged in the South Wales division of the Great Western Railway for some years. He had been much interested in Mr. Gattie's scheme, and had tried to see if it could work, but he had come to the conclusion that it was absolutely impossible in such a district. He had got out the record for one day of the whole of the traffic moved in the Cardiff district on the Great Western line, and he had found that 96 per cent. of it moved from one private siding to another private siding. How Mr. Gattie's machinery scheme was going to assist in dealing with traffic of this description he, as a practical railwayman of between thirty and forty years' experience, could not see. His company would be only too glad to introduce more labour-saving appliances for handling goods traffic if such were possible, and they would like to reduce the working expenses in that direction. The subject was constantly under review, and had been for years. There was one point which he would like to put to the author. The author proposed to run a coal train composed of 45-ton wagons to a country station. One got household coal, steam coal, smithy coal, anthracite and other coals. How did he propose to run all those coals in one wagon? Unless all the coal was in the national hands, and one could say to a particular district, "You are to have this household coal, or this steam coal, and this coal only," it was quite impossible to run the coal about the country in anything higher than a 10-ton wagon. It was difficult sometimes even to load a 10-ton wagon with a particular kind of coal, and it was impossible, he thought, to carry the coal in 45-ton wagons. Although the idea was an excellent one in theory, it would not work out in actual practice. In the matter of the general traffic of the country, the Great Western Railway had experimented with large vans 21 ft. and 28 ft. long, but they had found them most uneconomical,

except in very special cases, for the reason that, while a good load was obtained from London to the country, a return load was not available, and the vans were brought back empty. After mature consideration, his company was quite satisfied that the 10-ton wagon was the best wagon to accommodate the present general traffic in England, but if traders could be induced to deal with their business on a wholesale and not on a retail basis, then, and not till then, could larger wagons be profitably introduced. A previous speaker had put forward the figure that it cost 8*d*. a ton to move wool from London to Bradford, and that the balance of £2 11*s*. went in terminals, and that those figures had never been contradicted. He (the speaker) took the present opportunity of challenging them. The figure was absurd.

A MEMBER inquired if Mr. Ford had been to the Gattie works and seen the machinery at work.

MR. FORD replied in the negative, but added that he had read Mr. Gattie's pamphlets and seen his diagrams, and he understood exactly, from gentlemen who had been to the works, what the conditions were.

THE MEMBER said all the eminent men who had visited Mr. Gattie's works had come to exactly the opposite conclusion to Mr. Ford's.

MR. E. W. CHALMERS KEARNEY said he would like to reply to the two points raised by Mr. Ford. Mr. Ford had said that the Gattie machinery was of no use applied to the specific case of his own railway. That did not answer the claim which Mr Gattie had made that his system would be of use taking the railways as a whole. Mr. Ford had also said that the Gattie machinery was no good, but had gone on to say that the 45-ton vehicle was of no use because of the difficulty of mixing the various coals and commodities. That was just where the Gattie system would come in, because with Mr. Gattie's system of containers all the different coals or commodities could be put in one and the same truck in their respective containers. As for trucks having to come back empty from little wayside stations, it was well-known that those trucks which stood in the local sidings, stood there for a week or a fortnight waiting to be returned. Instead of having a truck standing in the local siding there might very well be a container.

MR. KELWAY-BAMBER, in reply, said, with regard to the Chairman's remarks, unfortunately he (the author) had not pointed out when explaining the topsy-turvy diagram he had exhibited, that he had been dealing not with the war period; the basis he had been working on was the line of advance from 1900 to 1913, and he had assumed that when normal working conditions returned, the grade would be of the same steepness as before. He quite realised that, if statistics had been available with regard to the amount of work that had been done by the railways and the loads which had been carried during the war, they would have shown a different state of things from what he had put before the meeting that afternoon. Wishing to be conservative he had based his estimate of post-war (1920–1950) advances on a continuation of pre-war progress. He had seen Mr. Gattie's system, and it had struck him as being admirable, so far as he had been able to judge its action in the laboratory. What it would have done in actual working he was not in a position to say. He hoped that Mr. Gattie's fate would be different from that of the proposer of the Daylight Saving Bill, who had had a very good thing to bring forward but who unfortunately never lived to see it adopted. Mr. Marillier had spoken of heated journals, and said he had no difficulty with regard to them. That he could quite believe, because when he (the author) had had great difficulty with regard to hot axles on Indian railways, he had gone to Mr. Marillier and had found the cure. But it was a fact that when one got beyond 20 and 25 tons the pressure on the journal, the hammering on the rail joints, etc., disturbed the bearings and, certainly in India, where the joints were not so good as in this country, they gave a good deal of trouble. His point was that the bogie vehicle would reduce the handling by at least one-half. Even if one took two 22½-ton wagons instead of one 45-ton wagon, one obtained the advantage of halving the number of vehicles which had to be dealt with. With regard to Mr. Ford's remarks, he knew there were many difficulties to be overcome, but it would be noticed that in the paper he had given a period of thirty years for their consideration and removal. He had not proposed that to-morrow every wagon in this country should be scrapped and 45-ton wagons installed. Difficulties were made to be overcome. So far as the coal merchant was concerned, he had read that in Winchester and some other towns during the war traders had pooled their requirements, and had got their materials down in large wagons. If a coal merchant required 10 tons of anthracite and 10 tons of household coal there was not the least difficulty, so far as he knew, provided the merchant was getting the coal from the same colliery, in putting in bulkheads in a 45-ton wagon and thus dividing the coal.

A MEMBER pointed out that the coals did not come from the same colliery.

MR. H. KELWAY-BAMBER, continuing, said that might be so, but he thought the difficulty could probably be met in that way. He had had the following very great difficulty to meet on the Indian railways. It had been necessary for a very special reason to increase vastly the dimensions of the rolling-stock, so much that the carriages which were originally 64 ft. were required to be 72 ft. The question had been put to him by the Military Secretary to the Viceroy, Could he or could he not extend the length of those carriages for Indian railways from 64 to 72 ft.? He had to give an

immediate decision, and he had replied in the affirmative. The royal train had been built 72 ft. per coach. The general manager of a line over which those coaches had to pass wrote to the general manager of his (the author's) line and gave formal notice that he would not accept them. He (the author) advised his general manager to reply that the royal train would be at the junction station, and that it was up to the general manager of the other line to take it or leave it there. Three weeks afterwards that general manager had written saying: "You will be pleased to hear that we have made a test, and it is perfectly satisfactory." The royal train went on every mile of broad-gauge track in India. When the tour had been completed, the Railway Board said: "Now that these long carriages can go all over the country, we have a great means of reducing working expenses by carrying a great many more people on four axles." The train, in five parts, was sent all over India; and when it came back they there and then laid down, on the lines mentioned at that momentary conversation with the Military Secretary, the maximum dimensions for future Indian railway trains, and from that time onwards coaches of those dimensions had been built. The traffic department at first objected to carriages of the new design, but later decided that they were exactly what was wanted, and two years' later they became the standard of the whole of the Indian railways broad-gauge system. So that, although there were difficulties to be met with in connection with the 45-ton wagons in this country, they could be gradually overcome and the changes which he had ventured to suggest in his paper were quite within reach.

On the motion of the CHAIRMAN, a vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

CORRESPONDENCE.

INDIAN INDUSTRIAL COMMISSION.

I have read with the greatest interest Mr. Chadwick's able paper on "The Report of the Indian Industrial Commission." I am sure we all of us ought to be greatly obliged to him for it. I congratulate the Government of India and the India Office upon his appointment. He possesses the great qualities of enthusiasm and vision which are so much needed—indeed, they are indispensable gifts for anyone who would deal successfully with the great problem of the industrial development of India.

I venture to say that the opinion of the Commission, as mentioned by Mr. Chadwick, to the effect that most European houses in India are more commercial than industrial, is entirely wrong. At all events, I am well aware of the fact that all the largest firms in Calcutta are pushing local developments far more vigorously than a mere buying and selling of imports and exports. When such a statement is made one wonders whether the Commission in the course of their pilgrimage happened to come across the firm of Bird & Co. For instance, certain recommendations are made in that report as to the institution of geological and engineering departments and a system of apprenticeships for technical and practical work, all of which are accomplished facts in the organisation of the firm I have just mentioned, and in passing I may say that Indian apprentices in the geological and practical mining work are doing remarkably well.

A large portion of Mr. Chadwick's remarks is devoted to suggestions as to the various ways in which Government might aid industry. This is a subject on which the firm I represent here can speak both with knowledge and feeling. Let me just quote three examples.

We have the example of Government encouraging competition in the supply of additional electrical power in a district where we, as pioneers, have already installed electrical plant of sufficient capacity to cater very fully for the immediate and future needs of the district.

Again, as pioneers of the tea-box industry in India we have experienced difficulty in getting proper treatment from Government.

And, again, in our bamboo developments also, which we have been carrying on at considerable expense for several years past, we are experiencing similar treatment. We find that representatives of British firms sent out from England are being accorded special facilities which were refused to us who have for many years been carrying out the spade work. The Government of India even now refuse to grant us a sufficiently long lease to enable us to make the working of our bamboo concessions a sound commercial proposition.

The above are, of course, illustrations of "how not to do it," but let me not be misunderstood. I am well aware that the Government of India are anxious to aid industrial development by every means in their power, and no one will be so foolish as to scorn any help that is to be obtained. On the contrary, such aid will be much appreciated and gratefully accepted. We must all work hand in hand for that great purpose; but the vital question is, What is the best way in which Government can aid industry, and what should be their settled policy? My belief is that for any real sound scheme finance can be obtained, and I would therefore deprecate grants in aid by the State by way of finance. Also, rather than a direct subsidy I would be disposed, except in special cases, to rely upon a carefully framed import tariff against foreigners to foster new and nascent industries and to protect existing ones. For instance, if a tariff had been in force some years ago, no paper from the Continent would have been dumped to the ruination of the local industry; instead of three or four paper-mills in India, by now that country might have had many more and all flourishing. I am told also that

some years ago a promising glass factory was ruined by Continental dumping.

But, after all, what is the use of embarking fresh capital and developing fresh industries if the transport facilities of the country are inadequate to cope with even the existing traffic? I wonder if there are enough wagons at the moment to cope with traffic in India? If so, it is quite exceptional. For the past thirty years, except upon at most four or five occasions, wagons have not been obtainable in sufficient numbers to deal with the traffic offering. The records of the various chambers of commerce for years and years are largely filled with appeals to Government to improve that lamentable state of affairs; always begging the Government to invest money in wagons, which, by the way, pay for themselves in three years. Industry has been more and more heavily taxed, and at least it might fairly claim that the funds realised from taxes on industry might be spent in improving its transport; but no, the scandal remains while money is spent on building a new ceremonial capital.

While on the subject of railways, it is appropriate that we should consider in connection with our problems in India the present move in this country towards nationalisation of railways. Not so very long ago such a proposal would have been laughed at, but it seems to be upon us in this country. In India, on the other hand, there are those who have for years advocated the nationalisation of the railways. In that country the railways, as a whole, are State property and leased to private companies, thus combining the worst features of State and private ownership, viz. the inelasticity of State methods and finance, combined with the legitimate but selfish profit-seeking of the private owner. In a country like India it appears to me that State-owned and State-worked railways are the proper thing; for, remembering that Indian produce relies on cheapness more than on quality, it is of paramount importance that transport should be as cheap as possible, even if necessary at the expense of speed.

It is, of course, impossible within the scope of this letter to cover the whole ground of Indian development, and I do not want to refer to the political situation, on which much can be said.

All we can hope for is that, in spite of recent political developments, the long-standing cordial relations between the European employer of labour and his employees may remain undisturbed, for upon those cordial relations hinges a good deal of the future prosperity and industrial development of India.

E. ALLAN IRONSIDE.

GENERAL NOTES.

INDIAN INDUSTRIAL COMMISSION REPORT.—In the House of Commons on April 30th, Colonel Yate asked the Secretary of State for India if he had received the resolution passed by the Indian Section of the Royal Society of Arts on March 13th on the subject of the Indian Industrial Commission's report, and the necessity of prompt action; and what steps he proposed to take to give effect to the proposals of the Commission. Mr. Montagu answered the first part of the question in the affirmative, and as to taking action referred Colonel Yate to the reply given on February 13th to Sir J. D. Rees. The Secretary of State added: "I expect to receive shortly a despatch from the Government of India on the subject." In his reply of February 13th Mr. Montagu stated that he had agreed to the appointment for the time being of Sir Thomas Holland, President of the Commission, as Industrial Adviser to the Government of India; but as regards the detailed recommendation of the Commission he was awaiting the considered opinion of the Government of India and the local governments.

WAR MEMORIALS AT THE VICTORIA AND ALBERT MUSEUM.—The first section of the exhibition of war memorials will shortly be held in the Victoria and Albert Museum. This exhibition is being organised under the auspices of the Royal Academy War Memorials Committee, with the co-operation of the staff of the Museum and that of the British Institute of Industrial Art. In addition to memorials of the past (mainly from the Museum collections), this exhibition will include examples, selected by the committee, of memorials executed in recent times by deceased and living artists. It is hoped to cover every category of decorative art and craft with which memorials might be concerned, not with the view of providing designs which may be copied or slavishly repeated, but rather of guiding the taste of the public in the selection of suitable designs and of qualified artists; the intention is also to suggest the various forms which memorials may suitably take. Special sections will be devoted to lettering and the literary form of inscriptions. All communications should be addressed to the Director, Victoria and Albert Museum, and marked "War Memorials Exhibition," and intending exhibitors will be sent forms and labels on application. It is hoped that the exhibition may be open towards the end of June. As the time is very short, it is important that all applications for forms should be sent in not later than May 31st.

PALM-SUGAR PRODUCTION IN MADRAS.—The number of palm trees which are usually tapped for palm sugar in the Madras Presidency is estimated by the Department of Agriculture as 2,500,000, and the yield of jaggery (crude sugar) therefrom as 35,000 tons (of 2,240 lb.). The total palm-sugar production of India, writes the United States Consul at Madras, is stated to be about 300,000 tons, of which Bengal produces about 100,000 tons, valued at £480,000. India's total production of sugar, both from cane and palms, is somewhere about 3,000,000 tons per annum. The area under sugar cane in Madras is less than 4 per cent. of the total area in British India, the United Provinces being the great producing area.

WOLFRAM.—One of the noteworthy consequences of the war, according to *Metall und Erz*, is the great increase in the output of wolfram. Before the war the whole world-production did not exceed 10,000 tons annually. The present output is at least double that quantity. An approximate estimate gives: Portugal, Spain, France, and Great Britain, 2,500 to 2,800 tons; North America, 6,000 tons; South America, 3,000 to 3,500 tons; India, Siam, the Malay States, and Australia, 5,500 to 6,000 tons; China and Japan, with Indo-China, 800 to 1,200 tons. The stimulus has been high prices, so that a drop in market value would close some of the mines. Russia certainly possesses deposits of wolfram. South America, Spain, and some other countries favourable to Germany may be expected to ship to her wolfram ore at prices considerably below the present abnormally high level.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

MONDAY, MAY 26.—CAPTAIN FRANK E. D. ACLAND, M.Inst.C.E., M.I.Mech.E., "A New Prime Mover of High Efficiency and British Origin." The Hon. SIR CHARLES ALGERNON PARSONS, K.C.B., LL.D., D.Sc., F.R.S., will preside.

WEDNESDAY, MAY 28.—HARRY J. POWELL, "Glass-making before and during the War." SIR RICHARD TETLEY GLAZEBROOK, C.B., Sc.D., F.R.S., Director of the National Physical Laboratory, will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.:—

JUNE 5.—BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aviation as affecting India." MAJOR-GENERAL THE RIGHT HON. E. B. SEELY, C.B., C.M.G., D.S.O., M.P., will preside.

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m.:—

MAY 27.—LIEUT.-COLONEL THE HON. SIR JOHN McCALL, M.D., LL.D., Agent-General for Tasmania, "Science and Industry in Australia."

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 26...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Extra Meeting.) Captain F. E. D. Acland, "A New Prime Mover of High Efficiency and British Origin."

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m. Annual General Meeting.

Geographical Society, Burlington-gardens, W., 8.30 p.m. Captain A. de C. Sowerby, "Recent Journeys in Manchuria."

East India Association, 7, Tothill-street, Westminster, S.W., 3.30 p.m. Rev. J. A. Sharrock, "Caste as a Factor in Indian Reform."

TUESDAY, MAY 27...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Lieut.-Colonel the Hon. Sir John McCall, "Science and Industry in Australia."

Royal Institution, Albemarle-street, W., 3 p.m. Professor W. H. Bragg, "Listening under Water." (Tyndall Lecture.—I.)

British Women's Patriotic League, 92, Victoria-street, S.W., 3 p.m. Sir J. B. Matthews, "From Island to Empire."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Mr. J. T. Cunningham, "On Result of a Mendelian Experiment on Fowls, including the Production of a Pile Breed." 2. Miss K. F. Lander, "Some Points in the Anatomy of the Takin (*Budorcas taxicolor whitei*)." 3. Mr. E. P. Allis, "On Certain Features of the Otic Region of the Chondrocranium of *Lepidosteus*, and Comparison with other Fishes and higher Vertebrates."

Colonial Institute, Central Hall, Westminster, S.W. 8 p.m.

Horticultural Society, Drill Hall, Buckingham-gate, S.W., 3 p.m. Mr. J. G. Weston, "Some Irish Gardens."

Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. Professor W. E. Adeney and Mr. H. G. Becker, "The Determination of the rate of Solution of Atmospheric Nitrogen and Oxygen by Water." (Part II.)

WEDNESDAY, MAY 28...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Ordinary Meeting.) Mr. H. J. Powell, "Glass Making Before and During the War."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

African Society, King's College, Strand, W.C., 5 p.m. Mr. R. E. Dennett, "Agricultural Progress in Nigeria."

Japan Society, 20, Hanover Square, W., 8.30 p.m. Miss J. M. Richardson, "English Ideas in Japanese Education."

THURSDAY, MAY 29...Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 2.30 p.m. Annual General Meeting.

Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Chadwick Public Lectures, at the Royal Society of Medicine, 1, Wimpole-street, W., 3 p.m. Colonel A. Balfour, "The Problem of Hygiene in Egypt." (Lecture II.)

Royal Institution, Albemarle-street, W., 3 p.m. Sir V. Chirol, "The Balkans." (Lecture I.)

FRIDAY, MAY 30...Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. F. W. Willcox, "The Gas Filled Lamp and its Effects on Illuminating Engineering."

Royal Institution, Albemarle-street, W., 5.30 p.m. Sir J. R. Bradford, "A Filter Passing Virus in Certain Diseases."

Mechanical Engineers, Institution of, Storey's-gate, Westminster, S.W., 6 p.m. Discussion on Dr. W. H. Hatfield's paper, "The Mechanical Properties of Steel, with some consideration of the Question of Brittleness."

SATURDAY, MAY 31...Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. M. Price, "The Italian Front." (Lecture I.)

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, at the Society's House, John Street, Adelphi, London, W.C. (2).

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—May 23, 1919.

No. 3471. MAY 30, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,471. VOL. LXVII.

FRIDAY, MAY 30, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

THURSDAY, JUNE 5th, at 4.30 p.m. (Indian Section.) BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E., "Aviation as affecting India." MAJOR-GENERAL THE RIGHT HON. JOHN E. B. SEELY, C.B., C.M.G., D.S.O., M.P., will preside.

EXTRA MEETING.

MONDAY, MAY 26th, 1919; The Hon. SIR CHARLES ALGERNON PARSONS, K.C.B., LL.D., D.Sc., F.R.S., in the chair. A paper on "A New Prime Mover of High Efficiency and British Origin" was read by CAPTAIN FRANK E. D. ACLAND, M.Inst.C.E., M.I.Mech.E.

The paper and discussion will be published in a subsequent number of the *Journal.*

COLONIAL SECTION.

TUESDAY, MAY 27th, 1919; Senator Hon. G. F. PEARCE, Commonwealth Minister for Defence, in the chair. A paper on "Science and Industry in Australia" was read by LIEUT.-COLONEL THE HON. SIR JOHN MCCALL, M.D., LL.D., Agent-General for Tasmania.

The paper and discussion will be published in a subsequent number of the *Journal.*

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 28th, 1919; SIR RICHARD TETLEY GLAZEBROOK, C.B., Sc.D., F.R.S., Director of the National Physical Laboratory, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Beresford-Jones, Captain Harry, M.B.E., J.P., Chester.
Pascall, Sydney W., London.
Peile, Henry, Newcastle-on-Tyne.
Rutherford, Walter, London.
Upton, Alfred Ernest, Sheffield.

The following candidates were balloted for and duly elected Fellows of the Society:—

Chakravarti, Rai Bahadur Gyanendra Nath, I.S.O., M.A., LL.B., Benares City, India.
Gardiner, Rev. Allan Frederick, M.A., Trichinoply, South India.
Gowan, Arthur Byram, Newcastle-on-Tyne.
Hyland, Alfred, A.M.I.E.E., Bombay, India.
MacKenna, James, C.I.E., I.C.S., London and Pusa, India.
Jackson, Sir Herbert, K.B.E., F.R.S., London.
Neil, Matthew Dale, Dalla Dockyard, Burma.
Richardson, Benjamin, Wordsley, Stourbridge.
Richardson, William Haden Arthur, Wordsley, Stourbridge.
Spivey, George, A.M.I.E.E., Weymouth.
Varley, Gilbert, M.Sc., Assoc.M.Inst.C.E., Birkenhead.
Vassar-Smith, Sir Richard Vassar, Bt., D.L., J.P., London.
Williams, Richard James, A.R.C.A., Worcester.

A paper on "Glass-making before and during the War" was read by Mr. HARRY J. POWELL.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on May 15th, 1919; SIR WILLIAM DUKE, G.C.I.E., K.C.S.I., in the chair.

THE CHAIRMAN, in introducing Professor Armstrong, remarked that indigo in India had had a long and very chequered history. About the end of last century, or the beginning of the present century, it had been in some respects fairly

prosperous, and there had seemed to be a vista of new prosperity when Java seed was introduced into India. At first it did very well. Large crops were made and great profits accrued. That only lasted a relatively short time, and then the position of affairs again deteriorated; at about the time of the outbreak of war it had fallen very low indeed, and it seemed doubtful whether it would be possible to save the remains of the industry. The war had introduced an entirely new aspect of affairs. Up to then indigo had been increasingly unable to compete with the German synthetic product, but when the war came that great source of supply had been cut off, and indigo for the time being had come into its own. Something was known of the difficulties with which the natural product had to contend, and the various reasons which made the dyeing trade and customers generally more inclined to take synthetic indigo than the natural product; and means had been sought to standardise the natural indigo, to make it more acceptable to the trade, and to put it in a position, if possible, to compete with the synthetic product. In the discussions that had taken place as to how best to set about that, Professor Armstrong had given the full weight of his assistance to the India Office. During the war indigo had got an unexpected and extraordinary chance, which had put it for a time in a position of monopoly, and which had enabled for a year or two enormous profits to be made from such indigo crop as could be raised; but even with everything in its favour the crop itself had not increased in any way in answer to the expectations, or what might have been expected to be a reasonable response to the enormous opportunities of profit. Professor Armstrong would explain the reasons why under so great a stimulus the production of the crop still lagged. It was impossible to disguise from oneself the fact that the prospects of indigo were not bright. It would very soon come into keen competition no longer perhaps with the German product, but with English synthetic indigo, and it was a question whether it would hold its own.

The paper read was—

SOIL DEFICIENCIES IN INDIA, WITH SPECIAL REFERENCE TO INDIGO. PHOSPHORUS AND THE FUTURE.

By Professor Henry E. Armstrong, F.R.S.,
Vice-Chairman, Lawes Agricultural Trust Committee.

In a recent course of Cantor Lectures which I had the privilege to deliver on "Problems of Food," I dealt at length with the experimental inquiries, carried out in recent years, by which it has been established that a variety of diseases to which man has been subject—such as beri-beri, scurvy and others, in which not only the nervous system but the processes of development generally are affected—are primarily conditioned by malnutrition. It has been proved by these inquiries, carried out, I may say, with living animals—which, I may add, could only have been carried out with living animals—that the cause has not been a deficiency of food in the ordinary sense of the term—that is to say, an insufficient amount of food—but that certain peculiar constituents have been absent from the food. It is recognised that these constituents, whatever their nature—which hitherto has remained problematical—are present in foods in very minor proportions; moreover, their distribution is very irregular. I have proposed that these substances should be termed "advitants." They are essential to growth and to our general well-being—vital necessities, in fact, as whatever the quantity of food at our disposal, if these constituents be not present, it is of little use to us.

It is highly probable that the low average state of physical development of the masses—bad teeth, in particular—is largely, if not in the main, a consequence of faulty nutrition; in other words, an outcome of our ignorance of the science of nutrition. At the moment, the talk is of housing as the social problem of primary importance; doubtless, better housing will lead to greater comfort but unless we realise that malnutrition—especially during childhood—is the primary cause of the degeneration we deplore, the improvement effected will be slight and quite disproportionate to the effort.

Thus far, three types of advitants have been distinguished. Two are known by the vague terms "Fat Soluble A" and "Water Soluble B"; A being associated, in nature, with fats; B being a principle which can be extracted from a variety of food materials by means of water. Food from which these substances are absent not only fails to promote growth in young animals but conditions rapid degeneration of the nervous system; they are, therefore, spoken of as antineuritic principles. The third principle is known as the antiscorbutic factor, as the symptoms of scurvy are rapidly developed in its absence—this is especially the case when no fresh vegetable food is available. This advitant appears to play an all-important part in the development of the teeth.

The ravages produced by scurvy in the Navy prior to the days of Captain Cook, who first grappled with the disease, also in times of famine, are well known. Our forces in Gallipoli and Salonica were serious sufferers; indeed, Candler states, in "The Long Road to Baghdad," that, in the early stages of the Mesopotamian

campaign, 50 to 80 per cent. of the troops were afflicted by scurvy. I mention these facts as showing how little attention has been paid hitherto, even by the medical profession, to such matters.

Beri-beri, an Eastern disease, has been proved to be due to the use of polished rice. In polishing rice, only a thin outer layer below the husk is removed; but this is sufficient to render it an incomplete food. Animals fed on polished rice show the symptoms of beri-beri*; these disappear rapidly, however, when merely an extract of the polishings is made part of the diet. In India, I believe, the kind of rice varies with the caste; some will not eat polished rice. Sir Mortimer Durand has told me, that at a time of famine he has actually seen the children allowed to starve rather than that they should eat the kind of rice which had been brought in from a distance —because it was not the rice of the caste; however, assuming the rice offered to have been polished, had they eaten it, probably there would have been little difference in the final result. It is clear, that it would be advantageous to abandon the use of polished rice entirely.

It has often been suggested that the development of many Western peoples has in some way been favoured by their high dietary; it is certain that their working efficiency is relatively high. Moreover, it has been found that the working efficiency, both of men and of draught animals, in Eastern climates may be raised by an improved diet. It would be an interesting study, if the attempt could be made, to correlate dietary with racial peculiarities in the case of a varied Eastern people such as inhabit the great Indian continent.

I have brought these matters thus prominently under notice in order that it may be clear that minor variations, in quality, in the food materials at our disposal may be of primary importance to us by most seriously affecting their nutritive value and that it is therefore important to consider how these variations may arise. That conditions of cultivation affect plants is a matter of common observation; but we have yet everything to learn as to the relative value of vegetable foods grown under these or those conditions. The work of Hall and Russell, in particular, has brought out very clearly the difference between neighbouring plots on the Kent marshes, the one being fit only for fatting sheep, the other for ewes suckling their lambs. There is no noticeable difference between them, in species, to be discovered; but the character of the herbage is different, the one being young and luscious, the other mature and spare. Probably, at first the plots were alike and the difference is the outcome of a difference in treatment over a long period; but the demands now made on the two plots must be very different, less being carried away from the soil by the fattening sheep and the return made in the form of fæces must be different. Passing to cattle, it is well known that, although there is much grass, there are relatively few fatting pastures; wherein the difference consists we have no idea. It has occurred to me lately, that peculiar advitants may be the cause of the difference; it is even conceivable that there may be negative as well as positive agents of this class. The whole subject is wrapped in mystery but that it is of the utmost importance there can be no doubt. Our future in hot countries may depend largely on the solution of the problem: the difficulty of rearing children in India, the poor health of the women living there, is well known—only the men who can keep in exercise seem to do well.

My former pupil, Mr. W. A. Davis, who went out to India as Indigo Research Chemist in the spring of 1916, tells me that not only has he found the food unsatisfying, but that, to his surprise, he has been obliged to eat considerably more than he did at home in England.

I was surprised by the large appetite the Europeans I met in Java seemed to have. Mr. Davis is inclined to think that much Indian food is deficient in phosphatic constituents. He points out that phosphates are largely administered, with success, to counteract the nervous ailments so rife there. He has dealt specially with the subject in a paper published in the special Indian Science Congress (1917) number of the *Agricultural Journal of India*, from which I reproduce the following suggestive extracts:—

THE RISK OF MALNUTRITION AND ENDEMIC DISEASE DUE TO THE IMPOVERISHMENT OF THE SOIL.

The impoverishment of the soils of Bihar in phosphate, as I have pointed out in an article in

* McCarrison, who has carried out a long series of experiments with pigeons at the Pasteur Institute of Southern India, finds that, in the absence of the accessory materials contributed by the outer layer of rice, not only are functional degenerative changes set up in the central nervous system, but that similar changes occur in every organ and tissue of the body. The symptom-complex is due to (*a*) chronic inanition; (*b*) derangement of the functions of the organs of digestion and assimilation; (*c*) disordered endocrine function; (*d*) malnutrition of the nervous system, and (*e*) hyperadrenalinaemia. The adrenals increase, whilst the thymus, the testicles, and other organs atrophy.—*British Medical Journal*, February 15th, 1919.

the *Agricultural Journal of India*, Vol. XII. Part II., has its effect not merely on the actual yield of the crops but on their quality.

Certain "deficiency" diseases, such as beri-beri and polyneuritis, are generally attributed to the use as main diet of polished rice containing an insufficient supply of substances essential for proper nutrition. The percentage of phosphoric acid is generally accepted as an index of the beri-beri producing power of a sample of rice. Rice containing 0·47 per cent. of phosphoric acid has been found to be a healthy food for fowls, whilst rice with only 0·28 per cent. brought about polyneuritis in a few weeks. The recent analyses of rices of Bihar by Mr. J. N. Sen (*Pusa Bulletins*, numbers 62 and 65) show that whilst a few of the polished rices examined contained from 0·4 to 0·5 per cent. of phosphoric acid, seven out of eighteen samples were dangerously near the beri-beri limit of 0·28 per cent., three samples containing less than 0·29 per cent. The sample from Sabour contained 0·27 per cent.

Now the deficiency of phosphoric acid in the rice grain is undoubtedly to be attributed to a deficiency of phosphate in the soil on which it was grown. Four out of five samples from Sabour showed very low values—0·27 to 0·33 per cent. and the Sabour soil contained only 0·11 per cent. of total phosphoric acid—a value which, however, is probably higher than would be given by many other soils in Bihar to-day. The phosphoric acid in the rice grown at Sabour was always far lower than that in a Hawaiian rice grown on a soil containing 0·48 per cent. P_2O_5.

It would perhaps be unsafe to prophesy that the continued depletion of the phosphates in the soils of Bihar will necessarily be followed by a spread of beri-beri but there is distinct danger that this may be so. There is, however, no question that the rices of Bihar and probably also other crops are deficient in a vitally essential constituent. There is, too, an intimate connection between soil impoverishment and malaria. In his recent "Report on Malaria in Bengal" (pp. 64–65), Dr. C. A. Bentley points out that the fever indices are highest "in areas in which harvests have been comparatively poor and where exhaustion of the soil necessitates frequent fallows"; and that fever increases as a direct consequence of agricultural deterioration. "In Bengal, soil exhaustion and agricultural deterioration are accompanied by an increase of malarial infection." In most cases it is probable that in Bengal, where beri-beri is fairly prevalent, the exhaustion of the soil, as in Bihar, is due to a deficiency of phosphates. If this were supplied in the form of a phosphatic manure there would be no necessity for frequent fallowings and more abundant crops would probably be obtained.

Malnutrition of Cattle, low Milk yield, and nervous diseases of Horses associated with deficiency of Phosphate.

There is, I think, no doubt that the poor quality of the cattle in Bihar and the low yield of milk is largely due to malnutrition owing to a deficiency of phosphate in the soil. It is well known that the supply of phosphate in the food has an enormous effect in increasing the yield of milk and dairy produce.

In Bihar the native buffaloes give not more than 3 seers of milk a day, sometimes rising to 5 seers, whereas in other districts, where better feeding conditions hold, the breed of cattle is far superior and the yield of milk is far greater. Thus the Jaffrabadi buffaloes in Kathiawar yield from 15 to 20 seers of milk a day, a good Delhi buffalo yields 25 seers and a Surat buffalo 16 seers or more (Mollison's "Text-Book of Indian Agriculture"). That the milk yield is not merely a question of breed appears from the fact that when such high-yielding buffaloes have been introduced into Bihar their milk has rapidly fallen off, so that, as a rule, there has been little introduction of outside stock.

Diseases of Horses.—In 1880 Dr. Wallace Taylor observed that epidemics of beri-beri in man were frequently associated with outbreaks of paralysis in animals. For many years, before being an agricultural research station, Pusa was run as a Government stud farm, but the results obtained were not satisfactory and it was finally abandoned, the reason being, I am informed, that the horses bred on this estate were lacking in vitality and subject to nervous disorders. There is no doubt that such forms of paralysis in horses as *kumri* are specially prevalent in Bengal and Bihar (*see* Hay's "Veterinary Notes," 1903, p. 543), and, as pointed out by Meyrick ("Horses in India," p. 63), *kumri* was very common amongst the Government brood mares at Buxar, where one of the late Bengal studs was situated. This disease has all the characteristics of a deficiency disease such as beri-beri.

It usually comes on gradually and sometimes a horse will remain only slightly affected for weeks or years. Treatment is useless in most cases, but according to Burke ("Tropical Diseases of the Horse," p. 58) change of situation always brings about an improvement. There is, therefore, a close parallelism with beri-beri and it seems highly probable that, just as in the latter case, phosphate deficiency is the cause. It is highly significant that in certain provinces, such as the Punjab or North-Western Provinces where the soils are more phosphatic, both diseases are rare and that in Bengal and Bihar, where it is known the soils are deficient in phosphate, the greatest number of cases come on towards the close of the rains (Burke, *loc. cit.*). It is at the same period that indigo "wilt" appears, a fact which I have explained as due to the washing out of the soil of the small reserves of available phosphates. At this period of the year the herbage would contain its minimum of phosphate, so that phosphate starvation would be most accentuated.

Fluctuations in the Growth of Indigo.

Before the war, in 1914, the area devoted to the indigo plant in India was less than 150,000

acres, whereas when synthetic indigo was first put upon the market by the Germans in 1897, the area occupied was 1,688,042 acres.

Up to 1897 the advance in the prosperity of the Indian industry was extraordinary; but from that period onwards a rapid decline set in, until in 1914 the amount produced was only about one-twentieth of the quantity made in 1896 and the total output became almost negligible.

EXPORTS OF NATURAL INDIGO FROM INDIA.

Year.	Cwt.	Value.
1894–5	166,308	Rs. 4,74,59,153
1895–6	187,337	5,35,45,112
1899–1900	85,460	2,08,78,818
From 1897 to 1906 there was a steady decline.		
1906–07	35,102	70,04,773
1911–12	19,155	37,58,025
1912–13	11,857	22,01,325
1913–14	10,939	21,29,070

When war broke out, arrangements were made to increase the production and the total area, in 1916–17, under cultivation was three and a half times that of the five preceding years. The greatest increase was in the Madras Presidency, where the industry was mainly in the hands of the small-holder, who, however, produced a very inferior quality of the dyestuff, containing only 40 to 50 per cent. of indigotin, the Bihar product containing 60 to 70 per cent.

In Bihar, an increased acreage of only about one-third was brought under cultivation; there was an actual slight falling off as compared with the average of the five years preceding 1915.

The conditions became changed during the latter part of the war, and in consequence of the stoppage of export, growers were no longer encouraged; now the Madras district, once more, is ceasing to produce; moreover, the total quantity of Bengal indigo available from last season's crop is only 1,600 chests (4,200 cwt.) and much of this, I believe, is not of high quality. And not only has the area under cultivation been small but there has been also a great diminution in the yield; the extent to which, during the past few years, this has been steadily falling is shown by the following figures:—

PHOSPHATIC DEPLETION OF SOILS.

Christopher Rawson, who was the first to study the problems of indigo cultivation and manufacture, on behalf of the Bihar Planters' Association, during the years 1898 to 1902, was led to the conclusion that many, although not by any means all, of the Bihar soils were deficient in available phosphoric acid. A large number of soils, sampled in 1907, were subsequently examined by Dr. Leather, who reported in 1908 that they were almost uniformly deficient in available phosphate, that is to say, phosphate which can be extracted from the soil by weak citric acid, the recognised method, introduced by Dyer, of distinguishing phosphate which can be taken up by plants from that which only becomes available very slowly.

At an early stage Mr. Davis was led to the conclusion that neglect of these warnings was the main cause of the difficulties which had been met with in the cultivation of indigo and of the undoubted falling off in the yield, especially of cereals, on many of the estates. He drew special attention to the danger ahead in the paper I have already referred to and also in the first of his indigo publications from the Agricultural Research Institute, Pusa. ("A Study of the Indigo Soils of Bihar. The urgent necessity of immediate Phosphate manuring if crops are to be maintained.")

He had found that no attempt had been made by planters to meet the deficiencies pointed out by Dr. Leather and that it had not been suspected that the more and more marked failure of the indigo plant to afford second cuttings, as well as the almost complete impossibility of securing seed from the Java plant, was due to the steady and continuous impoverishment of the soil. From a large number of new analyses of samples collected during the winter of 1916–17, it appeared that the soils were in a worse condition than when they were examined ten years previously. Many contained less than 0·0002 per cent. of available phosphate

TABLE OF YIELDS OF CAKE INDIGO PER ACRE.

	Bihar and Orissa.		Bengal.		Madras.	
	Acres.	Yield per acre.	Acres.	Yield per acre.	Acres.	Yield per acre.
		lb.		lb.		lb.
Average of six years—1910–1915	79,300	15·3	1,182	11	97,830	24
Season 1916–17	80,600	15	2,200	10	459,700	14
,, 1917–18	86,700	13	7,000	8	324,400	15
,, 1918–19	64,200*	11	10,000	9	139,100	22†

* This decrease was mainly due to agrarian trouble in Champaran.

† This apparent recovery in Madras is to be attributed to the survival of the better class of cultivation.

(the amount generally considered to be necessary for fertility in Europe is 0·01 per cent.) and in several not a trace could be detected; in these latter, crops died out shortly after germination.

The progressive character of the failure of the crops can be judged by an example taken from Belsand factory, where regular records have been kept. The Java variety of indigo (*Indigofera arrecta*) was first grown on this estate in 1904. An interesting account of ten years' experience with the plant is given by Mr. D. J. Reid, in the first number of the *Agricultural Journal of India* for 1917. Between 1904 and 1908 there was no pronounced failure of the leaf crop but that the soil was deteriorating rapidly may be inferred from the steady falling off of the seed yield, as given below:—

	Yield of indigo seed per acre.
1905–06 . . .	15 maunds.
1906–07 . . .	8 maunds.
1907–08 . . .	Yield disappointing.
1909 . . .	Very poor (less than 2 maunds).

In 1909 the green plant itself began to show signs of deterioration and the second cuttings failed more or less completely. In later years the first cuttings also began to fall off, both in quality and quantity, until, in 1912, there was a reduction of 65 per cent. in the yield of indigo as compared with that of 1908. In 1917, second cuttings failed generally and although the area under cultivation had been increased by 12 per cent. as compared with the previous year, the crop was estimated to be 5 per cent. lower. This failure was all the more remarkable as the climatic conditions were more favourable than those of the previous year.

From the large body of evidence as to the depleted state of the Bihar soils brought forward in his paper, Mr. Davis drew the conclusion that unless manuring with superphosphate were at once resorted to on a considerable scale, a very serious falling off of indigo crops, similar to that experienced at Belsand, will take place over a very wide area.

He has met with great variation in the total amount of phosphate in the soils but in most of them it has been present in an unavailable form. Frequently in fields quite close together on one estate, sometimes in different parts of the same field, the values for total phosphate may be nearly the same and yet those for available phosphate very different, as is shown by the following figures representing the amount present in the first six inches of soil:—

Estate.	Total P_2O_5.	Available P_2O_5.	CaO.
Byreah . . .	0·137	0·00505	9·10
	0·123	0·00057	11·17
	0·125	0·0002	9·20
	0·1075	nil	18·10
Rajpur . . .	0·1033	0·00252	24·04
	0·0864	0·00024	23·35
	0·0992	0·00004	18·24
Dholi . . .	0·124	0·0021	20·37

The suggestion has been made that the large proportion of calcium carbonate in the Bihar soils may vitiate the method of determining the available phosphoric acid by means of citric acid; but when the results given in the first and third lines of the above table are compared, which relate to two soils containing almost the same amounts of lime and also of total phosphate, it will be noticed that the available phosphate figures are extraordinarily different—0·005 in the one soil and only 0·0002 in the other. Taking the other results, it will be seen that some soils with a very high proportion of lime give far higher available phosphate values than those containing a far smaller proportion.

Mr. Davis is convinced, from careful study of a large number of individual fields on indigo estates, that the actual fertility practically always (putting aside those in which some other obvious cause of failure is apparent, such as the presence of salts, continued water-logging or a light, highly porous soil which fails to hold moisture) corresponds closely with the available phosphate values. In nearly all the soils examined the phosphate is the one constituent which is extraordinarily deficient—potash, lime, nitrogen and humus being present in relatively great excess.

Mr. Davis's explanation has been challenged particularly by Mr. Howard and it has been urged that defective aeration or water-logging are the real causes of failure. But against this is to be set the fact that all crops have been affected: moreover, the failure has been only of comparatively recent occurrence; it has come about gradually and it has been greater in extent and magnitude as time has gone on. Methods of cultivation and climatic differences are not likely to have altered in this way; moreover, well-drained, well-aerated areas have suffered as badly as those which are subject to flooding. Mr. Reid's paper abounds with evidence that the Java plant was not affected by floods in the early years of its cultivation: the deterioration has been general and progressive, not sporadic.

Mr. Davis's explanation, moreover, is rational

and in accordance with general agricultural experience. It is clear that no constituent of the soil is more necessary to the growth of the plant than is phosphate; and it stands to reason that it is indispensable, as phosphorus is a constituent of nuclear matter in plants and of nerve tissue and especially of the brain and spinal cord in animals.

But the dissension is unfortunate, as when doctors differ it is difficult for the outsider to distinguish between them; and such difference of opinion may tend to diminish the value of scientific advice in the popular mind. In part the disagreement has had this effect and conservative planters have preferred to follow in the wake of those whose advice may seem best to justify the practice they have adopted and would like to continue. Such should not be the attitude: doctors must differ, so long as there be opportunity for difference of opinion, so long as we have not reached finality of knowledge; the method of difference is the method by which eventually an understanding is reached and progress secured.

All problems under investigation must be envisaged in the broadest manner possible; the only possible attitude of the scientific worker is one of constant criticism; he must always be prepared to reconsider his judgments and to modify his opinions in the light of new evidence. It is not easy to do this. As the discussion is one involving issues of grave importances it should be brought to a head and I therefore have thought it desirable to refer to the difficulty openly on the present occasion. The following extracts from the reports of Mr. and Mrs. Howard show their attitude:—

MONTHLY REPORTS OF THE IMPERIAL ECONOMIC BOTANISTS.

(October—December, 1918.)

Indigo.—The investigations on Java indigo have now reached a stage when it is possible to draw definite conclusions as to the causes of the wilt disease and as to the methods of improvement by selection which are likely to lead to useful results in this crop. Incidentally, it has been found that the amount of available phosphate in the soil has no influence on the incidence of wilt. The results obtained are being prepared for publication, and the more important can be summed up briefly as follows:—

(1) During the monsoon phase, wilt in indigo can be produced by stopping the drainage in air-tight lysimeters either when the rains begin or at the period when the rise in the level of the ground-water takes place. The first result of water-logging is the destruction of the fine roots and nodules, which is then followed by wilt. Where free drainage is provided no wilt takes place.

(2) Under the rainfall conditions at Pusa, wilt is much more easily produced in Kalianpur soil than in Pusa soil. The Kalianpur soil contains about three hundred times more available phosphate than Pusa soil when both are analysed by Dyer's citric acid method.

(3) Both in lysimeters and in the field, the root system of Java indigo is profoundly modified by the condition of the subsoil as regards aeration.

(4) It is impossible to interpret field experiments on Java indigo in Bihar unless the root development and the condition of the subsoil are known with precision.

(5) Deep rooted types do not survive the monsoon and often do not shoot again after the first cut. The only methods of selection which promise success are those based on the isolation of surface rooted types. Four promising groups have been isolated which are being subjected to rigid selection.

These results confirm and extend the position we took up in the Third Report on Indigo published in 1916. The detailed study of the root system of this crop has proved to be the line of advance in the discovery of the causes of wilt and of the methods of selection which are possible in a crop which is self-sterile and which is composed of heterozygotes.

(January, 1919.)

Indigo.—For the fifth year in succession the continuous Java indigo plot has yielded a fine crop of seed in spite of a very unfavourable season due to the heavy rains in August just after sowing and to the early cessation of the monsoon in September. This plot has never received any superphosphate manure, nevertheless the seed crop continues progressively to improve and this year the seed now being picked is a very fine sample both as regards yield and quality. A good crop has also been obtained on a field lent by the Dholi estate. In this case also no superphosphate has been applied to the land and the present is the third crop of indigo seed which has been raised during the last three years. These results, as well as the experience obtained by using our modified system of pot culture, have proved that the limiting factors in the growth of seed of Java indigo under Bihar conditions are soil aeration and the supply of available nitrogen.

Taken as they stand, these statements are mere assertions: without particulars they cannot be criticised adequately. They do not carry conviction to my mind, and evidence is wanting that the problem has been regarded dispassionately and with the necessary breadth of outlook. That wilt can be produced by stopping the drainage and flooding no one will dispute. As to deep rooted types not surviving the monsoons, Mr. Reid's early

experience at Belsand, with Java indigo, gives convincing proof that they did survive on a large scale. As to seed being raised, year after year, on plots which have never received superphosphate, we are not informed what manure was applied to make such a result possible, nor what amount of phosphate was originally present in or was afterwards added to the soils. If the plots were steadily manured with oil-cake, as there is reason to think was done, the plant is not likely to have suffered from phosphate depletion, as such cake contains a considerable proportion of phosphate.

Java Indigo.

The Java variety of the indigo plant is deep-rooting, frequently going down 3 to 4 ft.; it therefore derives its nourishment mainly from the subsoil, whereas the cereal crops ordinarily grown are dependent chiefly on the surface soil. Without exception, in the case of the lands examined by Mr. Davis, on which there had been poor second cuttings or failure of August sowings for seed, the subsoil was almost entirely without available phosphate, even when the top layer was richer; invariably there was less than 0·0005 per cent. and in most cases less than 0·0002 per cent. in the subsoil.

Soils from several different fields and estates, on which the plant sown in August for seed had grown well until 12 to 18 in. high and then died down absolutely, when analysed, all gave the same result, the amount of available phosphate, in the surface layer, being comparatively high for the class of soil but almost nothing in the lower layers, as shown in the following table. In every case, the soil was light and well drained, not subject to water-logging:—

Available P_2O_5.	Field No. 16.	Field No. 4.	Field No. 1.
In top 6 in. of soil	0·00154	0·0012	0·0050
In second 6 in. .	0·0004	0·0003	0·0014
In soil 1 ft. to 3 ft.	nil	0·0003	0·0002

When the Java plant was first introduced into Bihar, in 1901, it was a remarkable success and it was thought that the industry might be saved by its general adoption. The leaf was far richer—nearly twice as rich—in indican, from which indigo is derived, than that of the Sumatrana plant and the crop per acre 50 per cent. higher. During the first three or four years the returns were extraordinarily high and it was being generally adopted; suddenly, in 1907, two diseases appeared simultaneously—the so-called wilt disease and the less serious insect pest "psylla." In consequence of the former—which led to the partial or complete loss of second cuttings—and of the failure of specially sown seed plant, it gradually became impossible to obtain sufficient seed for general use and the output of indigo fell off rapidly. Usually, disease appeared first or was most pronounced, on the lighter, sandy, high-lying soils, in which the drainage was best and the tendency to water-logging least.

Mr. Davis has been able to show, from Dr. Leather's analyses, which were made in the year 1907, when the wilt first became marked, that the disease broke out in soils abnormally deficient in available phosphate (below 0·0005 per cent.) and was not apparent in soils which were relatively better supplied (above 0·001 per cent.); these were attacked later on. It affected both the deep rooted Java plant and the shallow rooted Sumatrana variety.

The explanation of the success of the Java plant when first introduced and its subsequent failure seems simple. Being very deep rooted, it draws its nutriment largely from the subsoil. When first grown in Bihar there was a considerable supply of phosphate at its disposal in the lower strata of soil, which had been left untouched by the surface rooted feeding crops ordinarily grown and by the Sumatrana variety of indigo. It therefore grew remarkably well. At Belsand, in 1905, the uncut plant which was retained for seed was fully 7 ft. high—this after a deluge of rain of 67·56 in. from May to September. Mr. Davis speaks of a height of 10 to 12 ft. being frequently attained. The yield of seed was large. The plant gave so little trouble during the first four or five years, that it was often left undisturbed during two or three years, yielding two or even three cuttings regularly each season. Doubtless at this time the deep roots of the plant found a sufficient supply of available phosphate in the subsoil. Very few analyses were made in those days but in all the soils reported on by Rawson in 1899 (a year or two before the plant was introduced) the amount of available phosphate in the subsoil was practically the same as in the surface soil, as shown by the following figures:—

	Surface soil per cent. available P_2O_5.	Subsoil per cent. available P_2O_5.
Dooriah . .	0·013	0·015
Sathi . . .	0·021	0·021
Mosheri . .	0·010	0·008

The 1916 analyses of Tirhoot soils showed that more than two-thirds of the subsoils examined contained only 0·0002 per cent. or less of available phosphate. In other words, the subsoils had been so stripped that the proportion of

available phosphate present was only from one-fiftieth to one one-hundredth of the amount generally regarded as necessary for fertility.

Recovery of Soils.

Thus far, I have dealt with the case on the basis of the evidence supplied by the behaviour of the crops in the Bihar district and the condition of the soil as judged from the proportion of phosphate present in the available and unavailable forms. Turning now to the question whether it be possible to bring about a return to the high yields of indigo obtained formerly, Mr. Davis has accumulated much evidence from which it is clear that the necessary improvements can be effected by continuous and systematic treatment with phosphatic manures, provided these be properly applied, taking into account local peculiarities. He was able to quote a few instances in his Indigo Publication No. 2, and has added to these in No. 4. From his latest advices, I learn that instances are accumulating in which his forecast has been justified beyond question. The most valuable results are those obtained by Mr. G. Moore, of Moniara, Saran, who has kept careful records. The best crop was obtained on land manured with superphosphate and sannai (green hemp). The chief value of the experiments probably lies in the information that has been gained from them as to the effect of manurial treatment on the quality of the plant—in this case, its richness in indican. This consideration, although of supreme importance, has been largely overlooked hitherto; it is one to which I would invite particular attention in connection with my introductory remarks. Mr. Moore's results are summarised on page 454.

I may best quote Mr. Davis's comments on this table:—

The following points stand out very clearly as regards the effect of conditions of growth on the quality and yield of produce:—

(*a*) In the early June cuttings, a fortnight after the break of the rains, the quality of the plant grown on super and sannai was far higher than that grown under other conditions, as shown by the highest yield of cake indigo per 100 maunds of plant* (viz. 13 seers 15 chataks). But at this stage the plant grown on super and sannai was not fully developed and the yield of green plant per acre was lowest (94 maunds per acre). There was an enormous growth of plant on the *khuski* land and on the land manured with seet-water but although the plant was very tall it was of poor quality and contained little leaf.* The consequence is that the yield of cake indigo per 100 maunds of plant was very small (8 seers 0 chatak and 6 seers 11 chataks in these two cases). On the land manured with seet-water there was a rapid forced growth of indigo and the plant grew to a great height (8 ft.) but there was very little indigo in the plant. The consequence was that it took 593 maunds of green plant to produce 1 maund of indigo as against 284 maunds of the rich plant grown on super and sannai.

The plant grown on super and sannai was very much better in quality than plant grown on better land which had not been treated with manure but left fallow for twelve months—as shown by the yield per 100 maunds of plant being 13 seers 15 chataks as against 10 seers 14 chataks. Thus although the actual yield of plant per acre was slightly less (94 maunds 6 chataks as against 95 maunds 12 chataks), the actual produce of indigo per acre was considerably higher (13 seers 2 chataks as against 10 seers 5 chataks).

On June 18th, however, the plant grown on super had clearly not reached maturity and was not really ready for cutting. This is shown by the greatly increased yields obtained when the same plant was cut a fortnight later (July 4th). Consequently at the earlier stage (June 18th) the yield per acre (13 steers 2 chataks) was somewhat less than in the case of the *khuski* crop and the land manured with seet-water (yields 16 seers 12 chataks and 14 seers 12 chataks per acre respectively), where there was an enormous rapidly grown crop of poor quality.

(b) In the interval between June 18th and July 4th, there was heavy rain (15 inches) followed by a dry spell between June 27th and July 4th. In this period the plant grown on super and sannai developed considerably—the yield per acre increased about 60 per cent. (from 94 maunds 6 seers to 153 maunds 1 seer), whilst the quality judged by the yield of indigo per 100 maunds of plant was increased also to the same extent (from 13 seers 15 chataks per 100 maunds of plant to 21 seers 1 chatak). By the first week of July not only was the actual yield of green plant per acre far higher in the case of the super-treated land but the quality was also far superior, so that the yield of cake indigo per acre reached the phenomenal value of 32 seers 4 chataks per acre, for a single cutting.

This value is from two to three times that obtained from plant grown on the seeted land and mahaied at practically the same time (July 5th, July 6th and July 7th).

(c) The figures given for the average yield of cake indigo per acre dispose of the view frequently taken

* On the day this plant was worked the conditions were, too, most unfavourable for a good steeping, the water being exceptionally cold (83° F. instead of the customary 90° F.).

* The growth on these lands was forced by the high proportion of nitrogenous food in the soil. It grew to a great height (8 ft.), but the lower leaf was rapidly shed in consequence of unbalanced growth. As a result the plant in June largely consisted of stick and it gave a very poor yield of indigo. On the other hand, the plant grown on super and sannai, although fairly tall, was covered with leaf from top to bottom.

YIELDS OF INDIGO FROM JAVA PLANT AT MONIARA (1918) UNDER DIFFERENT MANURIAL CONDITIONS.

Date of mahai.	Treatment of land.	Acres cut.	Average yield of plant per acre.		Average yield of cake indigo per acre.		Quality of Plant. Yield of cake indigo per 100 maunds plant.		Quality of Plant. Green plant required to produce 1 maund indigo.		Remarks.
			Mds.	Srs.	Srs.	Ch.	Srs.	Ch.	Mds.	Srs.	
June 17	Kept fallow 12 months	10·47	95	12	10	5	10	14	368	0	This land was of better quality than that treated with super and sannai.
„ 18	Super and sannai	9·60	94	6	13	2	**13**	**15**	**284**	**20**	Steeping with very cold water (83° F.).
„ 19	Jamoona Singh's *khuski*	2·40	208	20	16	12	8	0	497	15	Java grew to tremendous height in these two fields—8 feet—but more wood than leaf.
„ 22	Manured with seet-water	3·05	218	28	14	12	6	11	593	0	
July 4	Super and sannai	4·01	**153**	**1**	**32**	**4**	**21**	**1**	**189**	**20**	Height of crop, 5 to 6 feet. Covered with leaf from top to bottom.
„ 5	Seet dug in with *kodali*	8·29	79	34	12	10	15	13	252	10	
„ 6	Seeted land sown in February along with Sumatrana	7·85	119	32	16	15	14	2	282	10	
„ 7	Seet dug in with *kodali*	13·09	84	11	11	7	13	10	293	0	
„ 8	Java of Bhoji Chaper mixed with February sowing	10·04	88	23	13	3	14	15	267	10	
„ 9	February sowing of Java	13·83	72	24	6	5	8	11	458	20	
„ 10	February sowing and Hiranda plant	12·22	78	4	11	2	14	4	279	20	

by planters, that the low yields of indigo recently obtained on most estates are due to deterioration of the Java indigo plant. It is clear that when the soil conditions are favourable (and these favourable conditions can, I consider, be largely assured by proper manuring) enormous yields of indigo can be obtained even in a year of unfavourable climatic conditions and with the existing Java plant. The yields per acre of 153 maunds of green plant and 32 seers of cake indigo for a single (moorhan) cutting far exceed the yields obtained from the Java plant in its palmiest days—shortly after its introduction into Bihar. Thus in the case of the extraordinary yield of 41½ seers of cake indigo per acre obtained at Bhagwanpur in 1906–1907, this was made up of three cuttings, which gave respectively 14 seers 9 chataks, 17 seers 4½ chataks, and 9 seers 12 chataks. Such a yield as 32 seers of cake indigo from a single moorhan cutting is, I believe, almost without precedent. The actual yield obtained at Moniara on land treated with super and sannai far exceeded my most sanguine expectations of what could be accomplished in a single season by proper manurial treatment. It cannot, of course, be expected that all lands will respond at once in the same marked way to manurial treatment but it appears to me certain that the majority of lands in Bihar can, by steady manuring for a few years, be made to yield 20 to 30 seers of indigo per acre in the course of the two mahais. This result will be attained not merely by increasing the yield of green plant per acre but largely by improving its quality, that is by allowing the plant to grow under conditions which bring about a maximum content of indican in the leaf.

It is not sufficient merely to obtain a rapid and abundant growth of green plant. Such a growth may be obtained by manuring with seet or seet-water or other nitrogenous manures such as cattle manure or oilcake. But the general experience of planters is that plant grown under such conditions has "nothing in it" and fails to yield good produce. This view is confirmed by the results, shown in the table, obtained on June 19th and 22nd, where there was a phenomenally large growth of plant in two fields (208 and 218 maunds per acre for the first cutting), but the produce per 100 maunds of plant was very low (8 seers and 6 seers respectively).*

From the results at Moniara it would appear that a combination of green-manuring with sannai and superphosphate is an ideal one to ensure not only a high yield of plant but also high quality. Whether this is so in general can only be decided by actual trials on the large scale. Unfortunately at Moniara no trials were made, for comparison, with superphosphate alone. There is the danger that abundant green-manuring with sannai may encourage a rapid and forced growth of plant at the expense of quality. That this was not the case at Moniara and that the nitrogenous constituents of the sannai only came slowly into action without forcing growth, is shown by the fact that on June 18th the yield of green plant per acre (94 maunds 6 seers) was only the same as on the fallow land (95 maunds 12 seers), whereas on the seeted and *khuski* land the yield of green plant at the same date was double as great (218 and 208 maunds respectively). But in the fortnight from June 18th to July 4th, the plant grown on the land treated with super and sannai grew rapidly and also improved enormously in quality. The final plant obtained, however, was never so tall as on the seeted lands in June—it only reached a height of 5 to 6 ft. as compared with 8 ft. on the seeted lands—but it was covered with leaf from top to bottom and the leaf was obviously very rich in indican.

The fact that even in this abnormal season, on the land manured with super and sannai at Moniara, such an extraordinary yield of indigo as 32 seers per acre could be obtained in a single cutting, even with the present Java plant, shows that the principal factor is apparently the soil condition.

Apparently the formation of indican is dependent mainly on a regular and balanced growth and a good supply of phosphate; it is certainly important to avoid an excess of nitrogen in the soil—nitrates especially, as in this case the plant may flourish, but without indican being produced.

Whenever indigo is raised, even from ordinary Bihar seed, outside Bihar, in good soil rich in available phosphate, the returns are still of the same surprising character as those obtained when the Java plant was first introduced into Bihar. Thus most remarkable results have been obtained in Assam, where indigo has been grown on newly cleared land; and considerable quantities of seed of the best quality have been raised there during the past few seasons, at the instance of Mr. Tunstall, mycologist to the Tea Association, under the direction of his wife.

It is being found, also, that the ordinary crops are benefited by phosphatic manuring—oats in particular. In small-scale trials last season, on about 20 acres, at Saraya, Captain Llewhellin obtained 12 maunds 2 seers per acre after application of superphosphate, as against 9 maunds on untreated land; Mr. Gale, of Champaran, who used about 10 tons of superphosphate last year, obtained nearly 20 maunds of oats per acre; and Mr. Mackenzie, of Sapaya, by five years steady manuring with superphosphate and green manure, has raised the average yield per acre from 10 to nearly 30 maunds.

Experimental Difficulties.

In the past, planters have often been discouraged by the irregularity of the results

* Compare also Rawson's data (Report, page 13). By manuring with seet (5 tons per acre) the yield of plant per acre was nearly doubled, but the produce per 100 maunds of plant halved, so that the yield of dye remained practically the same as on unmanured land.

obtained on using phosphatic manures. Apparently the conditions to be met have not been thoroughly understood and it is clear that there are special difficulties in the way of proper manurial trials in India. One chief reason is the extraordinary inequality of the soils; it is not safe, therefore, to base conclusions on a single trial. The only trustworthy method is to ascertain how the crop behaves in successive years under definite conditions of manuring. Often the result is only apparent in the second year. This has been shown to be the case in an important series of manurial trials carried out at Pusa during the years 1917 and 1918. I can only briefly refer to these.

The real difficulty now to be overcome lies in restoring phosphate to the depleted subsoils. In the case of light, sandy soils, apparently, superphosphate is readily washed down by the rains and an immediate response follows; but in very fine soils, like that at Pusa, the superphosphate is held, at first physically, in the topmost layer; and later, by the action of the lime which is present in large amount, it is changed into insoluble phosphate. The aim must be to maintain the phosphate in a soluble condition. In the Pusa soils, when superphosphate is used alone or in conjunction with a slow-acting organic manure like cake, there is little benefit apparent in the first year but the effect is obvious in the second; but when a large dressing of green manure is also applied, the whole benefit of the superphosphate is secured at once.

LIMITATIONS TO THE FUTURE OF AGRICULTURE.

The late Sir William Crookes, in his well-known address to the British Association at Bristol in 1898, drew special attention to the need of nitrogenous fertilisers, if the world were to be kept supplied with wheat; and he laid stress on the probable shortage of such materials. He may have exaggerated the difficulty, in view of the method of overcoming it, adopted by man from time immemorial, by growing leguminous crops in alternation with cereals. But in the interval, the difficulty has been met by the discovery of means of converting gaseous nitrogen, of which there are inexhaustible stores in the atmosphere, into either ammonia or nitrate: so long as there is power at disposal, we therefore need have no fear that there will be the shortage pictured by Crookes. But unless we always remain selfish, we shall forbid the waste of coal for such a purpose and insist on the work being done by means of water-power, which is ever running to waste; otherwise we shall be but robbing Peter to pay Paul and hastening on the day when our stores of energy will be exhausted.

A far more serious difficulty ahead than that foreseen by Crookes, although of the same order, is the smallness of the phosphate supply of the world—for that, apparently, there is no remedy. Therefore, the utmost economy must be observed in the use of this indispensable agent of our being to postpone the onset of general agricultural bankruptcy. We waste it, not only without a thought but with pride, when we lead it away to the sea in sewers and think ourselves superior, in consequence, to the "heathen Chinee"! Surely the proof is here, that a little knowledge is a dangerous thing; science imperfectly applied and very limited in extent is leading us to acts good enough in themselves, yet mayhap, most evil in their consequences. India is on the verge of starving for lack of phosphates: nevertheless her bones are being collected and sent abroad; at least the export of such an asset should be prohibited. And we at home should all do well to have a bone bag and see that such precious material is never wasted.

If the argument I have used at the outset be correct, we have yet to learn the full value of phosphates in agriculture, not only as to their influence on crop yield but also as to their effect on quality. Mr. Davis's suggestive remarks on the quality of the Indian foodstuffs become more suggestive, if considered in the light of the proof he has given that the proportion of indican in the indigo plant is affected by the proportion of phosphate in the soil. Thus far, although phosphate is known to be an essential foodstuff for animals, as it is for plants, there is no indication that the advitants in our diet, to which so much importance is to be attached, are phosphoric derivatives—if not, however, it is highly probable that phosphate and advitant are at least concomitant variables.

Other illustrations of the importance of the issue I am raising may easily be given. On the occasion of a previous debate in this room, that raised by Professor Farmer's paper * on "Science and the Rubber Industry," I referred to some of the impressions I had gathered during my visit to Australia and the East in 1914. In Australia, we had had the most striking illustration of the value of phosphates, particularly near Adelaide. The response to the application of phosphatic manures of the sandy soils of that district was very remarkable. Still more remarkable was that of the Mallee Scrub region

* *Journal*, Vol. LXVI. p. 490.

to the east: it was impossible to grow wheat on the land when it was first cleared, the yield was so miserably poor; but the smallest amounts of phosphate considerably raised its productive power. Much of Australia apparently is, as it were, boneless: it is a grave question whether the phosphatic materials required to make and maintain the fertility of large areas will be forthcoming; the extent to which Australia can be developed in the future must depend in no small measure upon the extent to which it can command phosphorus. A soil survey of the continent is an urgent need.

In Ceylon, I heard much of a coffee plant that was passed away and disconcerting statements as to the poverty in phosphate of the lateritic soils of the island. The passing of coffee may have been primarily the consequence of this poverty rather than of the arrival of a fungus: the constitution of the plant may well have been undermined through faulty nutrition, so that it eventually fell a prey to the fungus. The success of most fungoid attacks seems to be no mere consequence of the appearance on the scene of the attacking organism but rather of the susceptibility of the affected host. The possibility, nay, the probability, of this explanation was not disputed by those with whom I discussed the problem.

What has happened to coffee may well happen to rubber; at least the possibility should be inquired into very thoroughly. The plantation soils should be fully examined. On the occasion of Professor Farmer's paper, several of us deplored the inadequate consideration given to problems such as these and that so little was being done to develop the industry on a firm scientific basis. Has any action been taken in the interval to develop a sounder system?

One other consideration, but it is that which I had mainly in view when I undertook to bring this subject before the Society; yet it is one that I need not labour, as I have been anticipated by Mr. A. W. Hutchinson, the Government Bacteriologist at the Agricultural Research Institute, Pusa, who, seeing my title advertised, favoured me with an advance copy of a paper he was about to read at the Indian Science Congress in Bombay in January last. Mr. Hutchinson discusses the use of nitrogenous fertilisers and in so doing propounds the thesis that in a large number of Indian soils it is not so much the amount of nitrogen that is to be regarded as the limiting factor but rather the supply of phosphates and other essential fertilising materials: the use of nitrogenous fertilisers by themselves may easily lead to a lowering of fertility by determining and hastening the exhaustion of these other necessary agents. The argument is equally applicable to phosphate. The question thus raised is the root problem in agriculture; and if my contention be correct, it is more than a problem in agriculture—that is to say, if the lack of this or that material in the soil affect the nutritive value of the crops raised as well as the yield. The native, the world over, has learnt through the ages to till the soil in such a way as to grow crops at an even rate; a modern generation, with its puny knowledge of science, is come upon the scene and with entire selfishness, by the application of improved methods, is altogether changing the balance of nature and fast using up the stores accumulated over periods probably of great length, at the same time—as by killing off the sea birds—destroying the machinery by which they might be replenished.

If we are to continue our rake's progress, at least let us work with understanding; let us count the cost, see what forces are necessary and marshal them accordingly. One of our first cares must be that we take steps to provide an effective service for agriculture with as little delay as possible.

The Present Position of Indigo.

The situation may well be summed up in terms of the old adage that "you must first catch your hare before you cook him." The position appears to be by no means unsatisfactory, and may even be said to be promising. The conditions are now known under which the hare was raised, in days gone by, in the primest possible condition. It is clear what has happened, in the interval, which has led to his falling into a state of emaciation; and we fully understand what must be done in order to restore him to his former condition of fatness. Meanwhile, our methods of cookery have been considerably advanced, so that when he is again caught it will be possible to prepare him for the table with greater advantage than formerly. But enterprise and capital—imagination also—must be put into the operation. Whenever of late years a speaker in public has referred to what has been done with the aid of science, he has always told the same hackneyed story of the Germans putting a million into indigo before getting any return and the million is supposed to have been spent on scientific research. This country must be prepared to put some part of a million into the work, if it mean to

recover the industry. But the story of the Germans spending so much on research is probably based on imagination. If we could get at the facts we should probably find that the greater part of the money was used in paying the difference between cost of production and selling price; there is reason to suppose that prior to the discovery of the sodamide process, the manufacture of indigotin was not carried on at a remunerative cost. Commercial success was not secured, apparently, much before 1904.

DISCUSSION.

The Chairman (Sir William Duke), in opening the discussion, said he supposed there had been no period during the thirty years which he had spent in India when there had not been a chronic controversy going on as to whether the productivity of the soil had or had not deterioriated. He took it that the majority of the people who had discussed the matter had not been qualified any more than he himself was to judge of it, and much of what Professor Armstrong had said showed where the possibility of error and uncertainty lay; that was to say, it was very likely the case that the soil remained as fertile for certain purposes as it had ever been, but not as fertile for certain other purposes; that the absence of a very small and hardly detected constituent might make all the difference; that elements which the author called advitants might in past times have been present and resulted in excellent crops; and that the elimination of some small and almost imperceptible element might have led to what seemed an altogether disproportionate deterioration in some particular crop. He (the Chairman) would not be surprised if further investigation of that class of subject led to the elucidation of many things which had hitherto baffled people in India.

The Hon. Sir Claude H. A. Hill, K.C.S.I., C.I.E., Member of the Governor-General's Council, said he was glad of the opportunity of expressing the obligations under which they in India were to Professor Armstrong for the work he had done, especially in selecting Mr. Davis, who went out to India three years ago to investigate the chemical side in its relation particularly to the possibilities of commercial improvement. Mr. Davis had not confined himself solely to the commercial side of the problem, but had also made some very interesting suggestions as to other causes and considerations which had to be taken into account in forecasting the future of natural indigo. Without those suggestions they in India would have been at a very great disadvantage as compared with the situation in which they found themselves at the present time. As one outcome of Mr. Davis's contributions to the indigo problem, they had recently asked for the appointment to India of an indigo botanist to pursue specially the botanical side of the investigations in connection with cultivation. He had gathered from conversations with Mr. Davis that the main factor was now, and would continue to be, an agricultural question. It would depend on improved cultivation. Science, in relation to chemistry and the extraction of the indican content and so forth, could do a great deal; but the proportion of increase of production which was possible to science was comparatively small in relation to the degree of improvement of output which could be expected from improved methods of cultivation. That, of course, threw one back on the further question of how far intensive cultivation would be justified and could be continued indefinitely; but in so far as indigo was concerned, he understood from Mr. Davis that a very great deal was possible with the co-operation of planters and mere improvement in cultivating processes. As a result of improved methods of cultivation, and partly because of its utility in other directions, indigo, though comparatively a very small crop and of comparatively small value to India, might continue to hold its own in competition with the synthetic dye.

Major J. W. Leather, referring to indigo disease, said it became very pronounced about 1907, and the first appearance indicated that it was a leaf disease. His colleague, Dr. Butler, devoted about two years to the subject and drew blank. Professor Lefroy then hunted for the insect pest, and Mr. Hutchinson looked for the bacteria, but neither of those gentlemen could prove a true bill for the capital offence against either an insect or a bacterium. Mr. Howard then went into the matter from the agricultural point of view, and he asserted that it was not a disease at all, but merely a weakness which had been developed in the plant through a combination of three causes —namely, water-logging, want of aeration, and the extremely fine state of subdivision of the Bihar soil, which was supposed to interfere mechanically with the healthy action of the roots. With regard to water-logging, Mr. Bargtheil had been able to show that indigo had the disease on what was apparently well-drained land. As to aeration, perhaps he might refer to some work of his own. The work in question had to do only partly with indigo. It had to do with the total amount of gases in the soil, and it had been shewn that even after very heavy rain, soil was not badly aerated, or alternatively, if one assumed that because there was less oxygen or less gas in the soil under those conditions, nevertheless, plants were extremely healthy. Therefore, it could not be said that there was want of aeration. Then with respect to the idea of the soil being so extremely fine as to interfere with the mechanism of root action. The Bihar soils contained a high proportion of fairly fine particles, but they were rather deficient in excessively fine particles, so that that idea had been exploded. The net result of all those labours of

the scientists had been nil. Naturally the indigo planters had been very apt to say, in the words of the old adage, that while doctors were differing the plant was dying; but, as a matter of fact, while the doctors had been differing the plant had recovered in a great measure, and the disease, during that interval of several years, became very much less serious. However, during that time the other factor had been working—namely, the commercial factor of synthetic indigo—and the area of natural indigo had decreased until it reached about one-tenth of its original size. Then came the war and there had been a sudden rise in prices. Planters did their level best to get a larger area under crop, and he was glad to think that some of them had recouped themselves for many years of losses.

Dr. J. Augustus Voelcker said the author had stated that, just as with foods, soils might depend for their fertility upon the presence of a very small quantity of some essential constituent. Whether in the usual summary of the essential constituents of the soil everything had been included still remained open to question, because undoubtedly there were many agricultural problems which could not be explained by soil analysis alone. The question of the amount of phosphoric acid which occurred in soil was a most important consideration when a review of crops was being taken. He did not suppose that indigo differed from any other crop in that general respect. He certainly felt that very strong arguments had been advanced for holding that the poverty of the Bihar soils in phosphoric acid had an important bearing upon the failure of indigo to be a productive and beneficial crop; but that it had been proved that that was the real cause of the failure he was hardly prepared as yet to accept. Much had been heard of the differences between the authorities now in India, some putting it down to one cause and some to another, and a practical experiment had been quoted in the paper—but only one—and with it he was not altogether satisfied, because only one single phosphate had been used, namely, superphosphate, and it had not been used by itself, but only in combination with another material; so that it was still left open to question whether the benefit had been produced by the one or by the other or by a combination of the two. Until he saw further practical experiments carried out he should hardly be prepared to accept the views that had been put forward that afternoon. There were in India agricultural stations like that of Pusa, and the question might well be settled there. If it was true, as it probably was, that the poverty of the soils in India was due to the absence of sufficient phosphoric acid, and that the indigo crop suffered in consequence thereof, why should not a series of experiments be started at Pusa, and phosphates be used, not merely superphosphate but a number of different kinds of phosphate, and used in different quantities and combinations? The matter should be tested exhaustively. Though he certainly held that phosphoric acid was one of the chief needs of the soil, he was not prepared quite yet to accept the position that all one had to do was to apply phosphate to the land, and that the crop and the industry would alike recover.

Major Leather said that Dr. Voelcker had rather pointedly raised the question of the sufficiency of the work done in India. As a matter of fact it was not a question of one experiment only having been carried out—the one which Professor Armstrong had quoted—but there was abundant evidence so far as superphoshate was concerned that it is beneficial.

Mr. Bhupendranath Basu, Member of the Council of India, in moving a vote of thanks to Professor Armstrong for his paper, said he had come to the meeting hoping to hear of some remedy which might keep alive the moribund indigo industry. It was true that when the war had broken out artificial indigo became difficult to obtain, and planters got a good price for the indigo they grew during that year. Freight difficulties had not then arisen. But it had to be borne in mind that indigo planters had been losing heavily for many years, and that their outturn in that particular year had been very limited. The question then arose as to how far the planters could respond to the increased demand for natural indigo. In those days of 1914 everyone had believed that the war would be a short one, and that when it was over the German product would again be in requisition. In the meantime, if the planters had increased their output of indigo to a substantial figure it would have meant a large outlay of capital for which there would not have been any return if the old conditions came back after two years. Such money could not have been invested without some assurance that there would be an adequate return. Therefore, though the planters tried to make hay while the sun shone, they felt that the sun might not shine for any length of time. Then freight and exchange difficulties became very acute, and the stocks of indigo in India could not be exported, first for want of ships, and secondly for want of money. Then last year they had been faced with the further difficulty that the outturn had been very poor, from causes which were unknown. In spite of all those difficulties, however, a fair margin of profit had been made during the war, but that margin of profit he was quite sure would soon disappear. It had practically disappeared last year, and he did not know what the fate of the planters was going to be during the present year. It was cold comfort to be told by the scientists "We shall go on experimenting at Pusa to discover why indigo has suffered and how natural indigo may regain or maintain its position against artificial indigo, but you in the meantime go on spending money in acquiring plant and machinery and land for a prospect that may never be realised." He did not think it was possible to continue unless

the British Empire came to the rescue of the industry. When indigo had been declining he had tried on some of his lands other crops, notably tobacco, and he had found that if he could keep up the manuring of his soil, tobacco yielded him a more sure and a fairer margin of profit than indigo did. He had also tried chilies, but the great difficulty was to get a sufficiency of manure at fairly cheap rates. That was the difficulty in India—the procuring of sufficient quantities of manure at cheap rates, and about the use of which there should be no doubt by having demonstrations carried on on farms to which cultivators might be invited. Though he had the greatest pleasure in moving the vote of thanks, he had gathered but very cold comfort from the paper.

MR. T. MARTIN MACDONALD, in seconding the vote of thanks, pointed out that the whole system of cultivation had altered when the Java indigo was brought into India, and to his mind that had been the cause of the frightful deterioration of the soil. The old indigo used to be in the ground for only five months, when it was cut and cleared. After the introduction of the Java indigo it was, in some cases, three years in the ground. Perhaps two cuttings were taken off it, and then it was allowed to go to seed. Anybody who knew anything about cultivation could readily understand that that would exhaust most soils. Every planter in Bihar knew that the soils were particularly deficient in phosphates, but their difficulty was to get phosphates in any shape or form. In 1898 he had made inquiries as to whether there was any phosphatic rock in India, with a view to getting a concession, and was informed that such rock was known to exist in two places, but concessions had already been taken up: whether they had been developed or not he could not say. He had shipped superphosphates from this country on several occasions before Mr. Davis's appointment, but there was considerable loss in transit. He was informed that, at the present time, there were obstacles put in the way of intending shippers from this country. Another difficulty was the production of sulphuric acid in India. He hoped that the Government would prevent bones being shipped from India, as there was any amount of phosphate now required in that country.

The vote of thanks was carried unanimously.

PROFESSOR ARMSTRONG, in reply, said in regard to Dr. Voelcker's remarks he had merely quoted one set of trials in the paper out of the number that he might have mentioned, and he had given that particular set because there was a good deal of information in it. A large amount of work was being done at Pusa and other places, so that a good deal of evidence had been gathered to which he had not referred. As Mr. Macdonald had said, since the introduction of the Java plant, an altogether drastic change had been made in the methods of cultivation, which no doubt was the cause in part of the sudden breakdown. He did trust that Mr. Basu would take a little more hopeful view than he had expressed. His (Professor Armstrong's) own view was that the situation ought to clear; if all worked together there ought soon to be a reasonably good result; but a very curious situation had arisen, namely, that by making synthetic indigo in this country we had ourselves brought this into competition with the Indian product. That was a curious situation—that the two sections of the Empire should be working more or less against one another. It was now clear that the natural product had special properties as a dye, which gave it a certain advantage so long as heavy shades were being dealt with: that, he believed, was a factor that was going to play a part which had not been anticipated until recently. Evidence was now being got together which showed that "indigo" had an undoubted superiority for certain purposes; his impression was that indigo would always have a special value apart from synthetic indigotin, and that would prove to be a point of very considerable importance in favour of its production in India.

SIR LEWIS J. E. HAY, Bt., writes:—There is one point, and possibly a vital one, which apparently has escaped the notice of investigators until recently in their research work connected with natural indigo. Manufacturers of it in India work two distinct processes: (1) The fresh and living leaf process. (2) The dry and dying, or inert leaf process. The latter is worked in the Madras Presidency, but only when the leaf has to be stored for some days, or weeks possibly, owing to scarcity of water to work the fresh (living) leaf process. (3) Synthetic indigotin differs from either of the above, being obtained from coal-tar products—the produce of vegetation dead at least one million years. Here we have in itself an interesting bio-chemical problem, which becomes more interesting owing to its physiological and pathological connection. Dyeing tests have proved, and dyers have admitted, that the natural dye—obtained from the living leaves—is superior in dyeing strength to the synthetic obtained from dead vegetation, the synthetic being "anæmic" in comparison. May not this difference be due to an inherent difference in their respective energies, for "energy is indestructible, and is measured by work." Having regard to the known presence of vitamines in living vegetation, and absence from dead, it would seem to follow that they may be present in the produce of the living indigo leaves and absent from the synthetic. Laboratory investigations have so far, from necessity, in this country been carried out with indican obtained from dead leaves, giving results identical with synthetic, while the actual manufacturing process is one of vivisection of the living cut plant, containing indole or indoxyl in its leaves, while living, and not indican. I venture to suggest that the vitamine force may be due to alpha rays or particles, and that the latter are positive ions from the sun.

BULGARIAN CARPET INDUSTRY.

While carpets have been woven in Bulgaria for nearly 150 years, the production of the finer qualities dates from the "liberation" in 1878. Before that time Bulgaria was a Turkish province, and the product of its looms was for domestic use, little or no regard being had for the requirements of modern taste. Since then — and especially during the last ten years—progress in the industry has been so marked that Bulgarian carpets in design, texture, finish and style have surpassed those of Turkish, Rumanian, Serbian, or Greek manufacture. It is a fact not perhaps generally known that many of the best "Turkish" and "Persian" rugs and carpets are actually made in Bulgaria. In the Bulgarian factories many skilled Turkish weavers (both men and women) are employed, as well as expert weavers of other Eastern nationalities, but the majority of the workers are Bulgarians.

The Bulgarian Government has encouraged the industry in many ways, but chiefly by the establishment and maintenance of a school at Choumen for the technical education of those who desire to become skilled weavers. This school turns out expert weavers, who readily find employment at the private factories. The centre of the carpet industry is in the heart of the Balkan mountains, not far from the Rose Valley, where the famous attar of roses is distilled. There are large factories at Panaguerishte, Eski - Djoumaia, and Elena, under one director—the same Persian expert who established and directed the Government school for several years. One company operates large establishments at Panaguerishte, Koprivshtitza, Sopot, Teteven, and Tatar - Pazardjik under American management. There is another large establishment at Pirot under Siberian management, and smaller establishments at Klissoura, Karlovo, and Rahmanli.

In these factories, it has been ascertained, the annual average output of each weaver is about 33 square metres of the quality 300/300, or 19 square metres of the quality 400/400, or 12 square metres of the quality 500/500, or 10 square metres of the quality 550/550, or 8 square metres of the quality 600/600. Taking all sizes together, each weaver will turn out annually about 16 square metres of carpets (square metre = 1·196 square yards). This may seem a small output for the labour of a weaver for an entire year, but it must be borne in mind that what are known as Persian, Turkish, Serbian, Greek, and Rumanian carpets are woven with infinite care and study of colour, design, texture and finish.

In the factories referred to there are a trifle over 400 looms, many of them of so great beam that carpets 35 ft. and even 40 ft. in width are woven, the work being all done by hand. Last year about 1,200 hands, mostly women and girls, were employed in these factories, but in normal times the number is much higher. Thousands throughout the country work at home turning out on small narrow hand-looms rugs and carpets for local use, carpet-weaving being still a home industry in Bulgaria.

According to a report by the United States Consul-General formerly at Sofia, one great advantage the industry possesses in Bulgaria is the exceptionally fine native wool, which, when cleaned, finished and woven into carpets, retains its natural lustre. Persian carpets are particularly valued for this very quality, but the Persian expert, who formerly managed the Government school and now owns his own factories, considers that Bulgarian wool from the districts around Adrianople, Karnobat and Jambol surpasses Persian wool in that respect.

In the manufacture of these fine carpets in Bulgaria, American cotton yarns are used for the warp, as they have been found more even and more durable than those formerly brought from India. The yarns are dyed 100 kilogs (220 lb.) at a time in each required colour, the advantage being that the finished carpets from end to end are free from spots, specks, and unpleasant variations of the same colour.

It is proposed in the near future to utilise in the carpet industry native Bulgarian silk. Special attention has been paid for years past to the cultivation of the silkworm, the production of cocoons having enormously increased of late years. The valley of Maritza, from Philippopolis to Dedeagatch, is one succession of groves of mulberry trees.

The owner of the group of factories at Panaguerishte is contemplating the erection of a spinning plant, which will not only be able to supply the entire neighbourhood with the 500,000 lb. of woollen yarns annually consumed in the home industry, but will also furnish at a much lower cost the finespun yarns required by the factories.

GENERAL NOTES.

The British School at Rome. — The open examinations for the Rome scholarships in architecture, sculpture and decorative painting (offered by the Commissioners for the Exhibition of 1851), and for the Henry Jarvis studentship in architecture (offered by the Royal Institute of British Architects) due to be held in 1915, but postponed on account of the war, will be resumed in 1920 under the direction of the Faculties of Art of the British School at Rome. The age limit for the 1920 competitions will be increased to thirty-five years. The last day for submitting work for the open examinations will be January 31st, 1920. The Rome scholarships, value £250 per annum and tenable for three years, are open to British-born subjects of either sex. The Jarvis studentship, value £200 per annum and tenable for two years, is limited to students or associates of the Royal Institute of British Architects competing for the Rome scholarship in architecture. The Com-

missioners for the Exhibition of 1851 have undertaken to award, on the recommendation of the Faculties of Art, additional travelling studentships, value £100, for meritorious work done in the final competitions for their scholarships in 1920. The Faculty of Engraving of the British School at Rome will hold a competition early in 1920 for a scholarship in engraving, value £250 per annum and tenable for three years. Candidates must be British subjects, and less than thirty years of age on July 1st, 1920. Particulars regarding the competitions may be had on application to the office of the British School at Rome, 54, Victoria Street, London, S.W. (1)

Brass-making Furnace.—An electric melting furnace that may revolutionise the making of brass has, according to the *Board of Trade Journal*, been perfected by the Bureau of Mines, but it has not been put on the market for profit. It is known as the Rocking Electric Furnace, and patents have been taken out by the Bureau. The new furnace is the result of five years' experiments by the chemist of the Bureau, in co-operation with the Cornell University, the American Institute of Metals, and a number of manufacturers of brass. Up to the present most brass has been made in the United States in costly crucibles of imported clay and graphite. Since the war it has not been possible to obtain the imported materials for crucibles, and manufacturers, it is stated, have had to put up with a very inferior brand at a cost many times over that of pre-war times. It is estimated that the unnecessary losses in brass-making are more than 3,000,000 dollars a year in normal times, and perhaps 10,000,000 dollars in war times. The Bureau of Mines states that it is inevitable that the next few years will see electrical furnaces, and there will be a development comparable to that seen in the steel industry in the last few years.

Diamonds in German South-West Africa.—From an article in the *Board of Trade Journal* for April 3rd it appears that in 1913 the yield of diamonds in German South-West Africa was 1,284,727 carats, worth £2,698,500, or 20 per cent. in value of the entire output of the world. Between April, 1908, when the deposits were first made known, and August, 1914, 5,400,000 carats had been recovered, their value being £9,250,000. One stone found by the Germans was 34½ carats, but the average size is a fifth to a sixth of a carat. The richest and most accessible deposits have been worked out, and although the recovery of diamonds is likely to continue for some time, the "life" of the fields was not expected by the Germans to last more than twelve or fifteen years. No important new areas have been discovered since 1910, in spite of vigorous prospecting. In some cases the profits have been almost incredible. One company during four years distributed dividends amounting in the aggregate to 112 times its capital of £5,025. In 1912 the dividend was 3,800 per cent., and this after payment of the heavy tax imposed by the Government.

MEETINGS FOR THE ENSUING WEEK.

Monday, June 2...Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Mr. E. W. Maunder, "The Mosaic Calendar as a means of dating approximately certain Ancient Writings."

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Mr. C. Turnor, "Land Nationalisation."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Geographical Society, at the Alpine Club, 23, Savile-row, W., 5.30 p.m. Anniversary Meeting.

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Annual Meeting.

Electrical Engineers, Institution of, at the Chartered Institute of Patent Agents, Staple Inn Buildings, Holborn, W.C., 7.30 p.m. Major K. Edgcumbe, "The Vicious Circle of Increasing Prices."

Tuesday, June 3...Rontgen Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. 1. Annual General Meeting. 2. Mr. N. E. Luboshey, "The Photographic Side of Radiography and the Use of Intensifying Screens."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Senatore G. Marconi, "The Continuous-Wave Plant at the Carnarvon Station."

Royal Institution, Albemarle-street, W., 3 p.m. Professor W. H. Bragg, "Listening under Water." (Tyndall Lecture.—II.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

British Women's Patriotic League, 92, Victoria-street, S.W., 3 p.m. Mr. A. Bigland, "The Fateful Moment."

Wednesday, June 4...Geological Society, Burlington House, W., 5.30 p.m.

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. W. W. Watts, "The Chalice: its History and Evolution."

Thursday, June 5...ROYAL SOCIETY OF ARTS, John street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Brigadier-General Lord Montagu of Beaulieu, "Aviation as affecting India."

Pottery and Glass Trades' Benevolent Institution, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m.

Chemical Society, Burlington House, W., 8 p.m 1. Mr. W. H. Perkin, "Cryptopine." (Part II.) 2. Mr. P. Blackman, "An isotonic (isosmotic) apparatus for comparing molecular weights." (Part I.) 3. Mr. V. Cofman, "The 'Active Substance' in the iodination of phenols." 4. Mr. N. V. Sidgwick, "The influence of orientation on the boiling-points of isomeric benzene derivatives." 5. Mr. J. Senior, "The atomic weight of iodine, and the discovery of a new halogen." 6. Mr. H. Hepworth, "The absorption spectra of the nitric esters of glycerol."

Royal Institution, Albemarle-street, W., 3 p.m. Sir V. Chirol, "The Balkans." (Lecture II.)

Chadwick Public Lectures, at the Royal Society of Medicine, 1, Wimpole-street, W., 3 p.m. Lieut.-Colonel A. Balfour, "The Problem of Hygiene in Egypt." (Lecture III.)

Friday, June 6...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor Sir E. Rutherford, "Atomic Projectiles and their Collisions with Light Atoms."

Geologists' Association, University College, W.C., 7.30 p.m. Dr. W. D. Lang, "Old Age and Extinction in Fossils."

Philological Society, University College, W.C., 5.30 p.m. Dr. H. Bradley, "Dictionary Evening."

Saturday, June 7...Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. M. Price, "The Italian Front." (Lecture II.)

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—May 30, 1919.

No. 3472. JUNE 6, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,472. VOL. LXVII.

FRIDAY, JUNE 6, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

THE SOCIETY'S ALBERT MEDAL.

The Council, with the approval of His Royal Highness the Duke of Connaught and Strathearn, K.G., President of the Society, have awarded the Albert Medal for the current year to Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S., "in recognition of his work as the pioneer of wireless telegraphy."

INDIAN SECTION.

Thursday afternoon, June 5th; MAJOR-GENERAL THE RIGHT HON. JOHN E. B. SEELY, C.B., C.M.G., D.S.O., M.P., in the chair. A paper on "Aviation as affecting India" was read by BRIGADIER-GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., V.D., F.R.Met.Soc., A.Inst.C.E., A.I.Mech.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

MONDAY, MAY 26th, 1919; The Hon. SIR CHARLES ALGERNON PARSONS, K.C.B., LL.D., D.Sc., F.R.S., in the chair.

THE CHAIRMAN, in introducing the author, said that everybody had noticed the steam which issued from the top of radiators on motor-cars and motor-buses, and to all engineers who thought about things it had occurred that that entailed a very serious waste of energy and of good heat. The author had devoted many years of research, in association with Mr. Still, to remedying some of the chief defects and blemishes on that most economical engine, the internal-combustion engine. Those gentlemen had succeeded in utilising a great part of the energy in that steam which came from the radiator. They had also tackled another drawback in the internal-combustion engine —namely, its want of elasticity for many uses, notably locomotives. The internal-combustion engine, when it was overloaded, gave up work; and in conjunction with utilising that steam they had obtained a reservoir of power in the steam which was able to withstand a very large overload for a short time and rendered the internal-combustion engine much more suitable for use in the propulsion of ships and also for locomotives.

The paper read was—

A NEW PRIME MOVER OF HIGH EFFICIENCY AND BRITISH ORIGIN.

By FRANK E. D. ACLAND, M.Inst.C.E.

The reconstruction of industry, and the reparation of the damage and waste of war, are occupying, and must long continue to occupy, the serious attention of the civilised world. Economy and efficiency are the basis of prosperity, and industry will depend more than before on technical and scientific workers to ease its burthens, shorten its hours of labour, and raise the living standard of those engaged in it. This country has shown in the past, and still shows, that it possesses technical and scientific ability second to none; but it often gives scant encouragement to new developments or new principles, until competitors in other lands have proved them of practical utility and profit. At the same time the expenditure of energy and capital on new things, whose underlying principles are intrinsically unsound, is incalculable.

The necessity for the conservation and economical use of fuel by every means is at last fully recognised by the Government; but every man, in all branches of technical and scientific work, hopes that "freedom, self-determination and progress" will not be smothered by too many committees and Government officials.

The interim report on electric supply, issued last year by the Coal Conservation Committee

(Appendix A.), estimates a coal consumption of 5 lb. per h.p. hour (about 4 per cent. thermal efficiency) as being a reasonable average consumption for the horse-power used in the country in factories, mines, and railways, and suggests that by the substitution of general electrification it might be reduced to 1½ lb. (about 12 per cent. efficiency). The improvement of the efficiency of the prime movers which supply the power seems even more important than the method of its distribution and application. If the fuel efficiency claimed in that report for electrification can be doubled, the saving of coal consumed per annum in these industries alone would amount to 68 million tons for the same output of energy.

There are two methods of producing power by the combustion of fuel—either under boilers or within the main cylinders of combustion engines. The greater part of the world's power is still derived from steam, which, owing to its proved reliability and greater adaptability to the services demanded of it, holds the field in competition with its rival—the internal-combustion engine. The steam engine exerts powerful starting efforts; puts trains or other masses into motion; operates at any speed from start to its designed maximum; can develop more than its rated power at reduced speed; can carry severe overloads for long periods, and generally gives ample warning before ceasing to operate: but this is accomplished with a loss of 80 per cent., at least, of the heat energy contained in the fuel supplied to it—a loss which is irrecoverable.

The internal-combustion engine shows a far higher heat efficiency, but cannot start itself without some external source of power; cannot develop its full power except at full speed; is a poor performer at low speeds; can only operate on moderate overloads for short periods; and may cease to operate, owing to a small defect, without warning; so combustion engines have as yet made little progress in competition with steam in locomotive work, and have supplanted steam but to a limited extent in marine and stationary engines.

The conversion of heat into useful work, with the minimum of waste, depends on the efficiency of the means employed, that is to say, it depends on the losses in the heat cyle, and on the losses in the mechanism employed for producing the heat and converting it into power.

"The efficiency of a heat engine is the ratio of the heat converted into mechanical work to the total amount of heat which enters the engine." So we are taught, and we owe to our teachers a mass of accurate information about the laws of thermodynamics, thermal and ideal cycles, which serve as standards of comparison for every kind of heat engine; but they do little

COMPARATIVE EFFICIENCIES OF PRIME MOVERS.

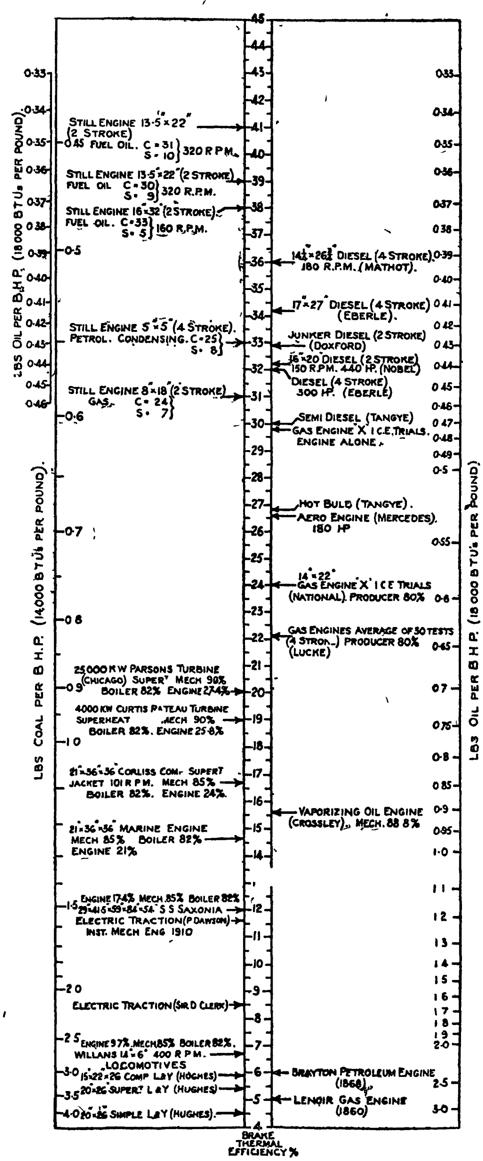


FIG. 1.

more than point out the way to getting the most out of the heat in an ideal engine, and ignore the losses in the creation and supply of the heat, or in the machine which converts it into mechanical work. It by no means follows that an engine, which thermodynamically attains the highest indicated efficiency in relation to the

ideal, is in practice the most efficient for its purpose, or the most economical in fuel. Efficiency from the user's point of view is the ratio of the useful work to the total heat in the fuel used.

Fig. 1 shows the brake thermal efficiencies of various types of prime movers—steam, gas, and liquid fuel, with the fuel consumption in lbs. per shaft horse-power hour, based on a calorific value of 14,000 B.T.U.s per lb. for coal, 18,000 B.T.U.s for liquid fuel. The mechanical efficiencies of the various engines, and heat efficiencies of the boiler and producer, when not expressly stated in the reports of the trials, are assumed to be as shown.

Comparing the cycle of steam with that of combustion engines, the latter has two great advantages over the former. The fuel which imparts the heat to the working fluid is introduced directly into its working cylinder, and the temperatures and pressures are far above the limits of those possible in the steam engine and boiler.

The steam engine suffers from heavy heat losses in the creation of its heat; it is forced to work at comparatively low temperatures and pressures, and with superheating, compounding and condensing added to it, has arrived at a point where further efficiency is well-nigh impossible.

Sir Dugald Clerk, in his paper submitted to the Royal Society of Arts in March, compared the thermal efficiency of the gas engine—28 per cent.—with an efficient producer, with that of the largest and best of existing steam turbines—18·5 per cent.—referred to the coal consumption under the boiler, and alluded to the probability of great improvements in gas engine efficiencies. The further recovery of thermal loss in the steam engine, or in the mechanism, is a difficult, if not an almost impossible task. In the internal-combustion engine all the losses at present existing are capable of some recovery, and certainly of considerable reduction.

The maximum ideal efficiency of a heat engine is obtained where the difference existing between the highest and lowest temperatures of the working fluid is greatest in proportion to the maximum temperature, and here the internal-combustion engine, with an initial temperature higher than the furnace temperature of the boiler, and even higher than the melting-point of cast iron, is capable of realising better thermal conditions than any other form of heat engine; but in its turn it suffers from two disadvantages—it ejects its working fluid at a temperature too high for ideal conditions, and it loses heat energy to a regrettable extent in the cooling of its cylinder.

The result obtained in practice from the two cycles separately, based on their best performances after half a century of intensive development, is that in the steam engine there is a loss of over 80 per cent. of the heat contained in the fuel, and in the combustion engine of 60 per cent.

The recovery and efficient use of the waste has been the work of many years of patient research by William Joseph Still and others associated with him, and has resulted in the design and construction of a variety of engines which bear out the correctness of his principles, and point to a vast field of further practical application.

The possibility of combining in one engine the superior thermal cycle at the high temperatures and pressures of the combustion engine with the low thermal cycle of steam to deal with its rejected heat, and, in the same engine, to add the superior working advantages of the steam engine, was the basis of his work.

The development of the internal-combustion engine has included many proposals and attempts to utilise the heat going to waste in the exhaust and cooling water; but while in existing engines some proportion of the heat can be usefully recovered as steam from the exhaust gases, the cooling water from the jacket is of little value, owing to its low temperature, and the efficiency of the engine itself is not augmented. If, however, the temperature of the cooling water could be maintained at that of steam at useful pressure, the efficiency of the engine would be improved and the weight of steam be usefully increased.

It has been inadvisable during the past four and a half years to allow publication, but the time has arrived when the principles of this new development should be available for examination and discussion, and an account be given of some of the results achieved. The delays and difficulties during the past few years can only be fully appreciated by those who have taken an active share in meeting, and to some extent successfully overcoming them; but it will be evident from the summary which follows that the results already obtained from engines which are admittedly experimental types, constructed under disadvantageous conditions, are sufficiently remarkable to substantiate their claim to be of real importance, while they give promise of far wider application and further

improvement in the drawing offices and shops of great manufacturing concerns.

THE STILL ENGINE.

The Still engine is an engine capable of using, in its main working cylinder, any form of liquid or gaseous fuel hitherto employed; it makes use of the recoverable heat which passes through the surfaces of the combustion cylinder, as well as into the exhaust gases, for the evaporation of steam, which steam is expanded in the combustion cylinder itself on one side of the main the quantity of steam which can be generated per horse-power developed by the combustion cycle, the lower must be the heat efficiency of the whole machine.

Internal-combustion engines are kept cool by the circulation of cold water round their cylinders; the heat thus absorbed causes a rise in temperature of the water as it travels through the jacket, so that the cylinder is subjected to temperature differences and heat stresses, which are an abiding source of trouble and difficulty to the designer.

In the Still engine (Fig. 2) the jacket and

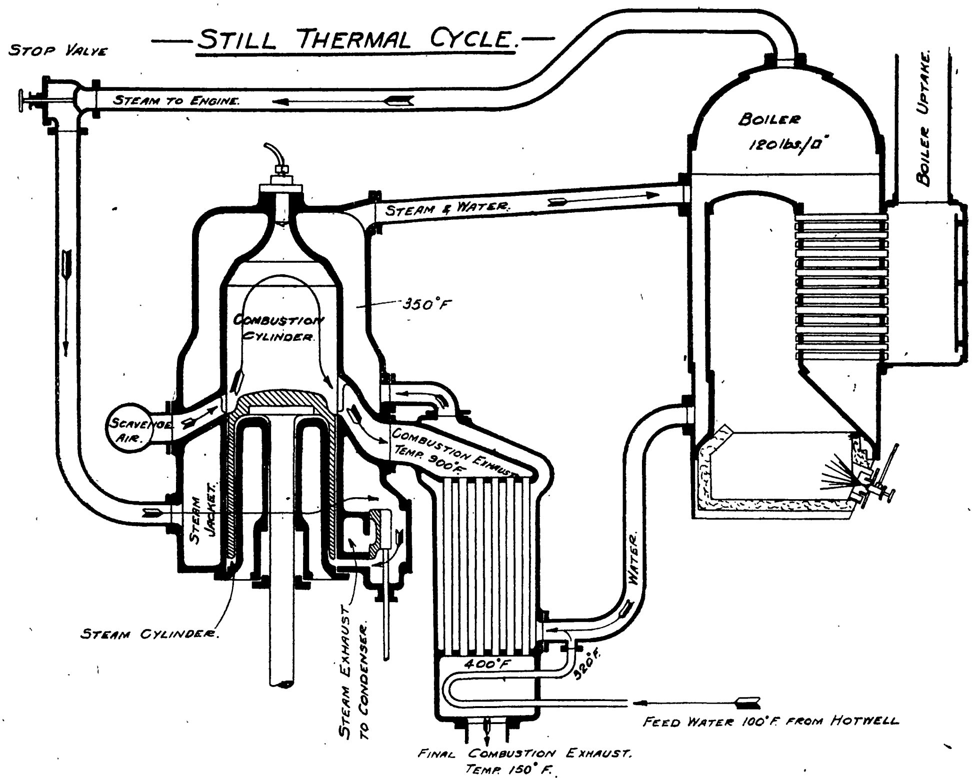


FIG. 2.

piston, the combustion stroke acting on the other side. It increases the power of the engine, and reduces the consumption of the fuel per horse-power developed.

Its primary object is not to use the waste heat for raising steam, but first to use it in improving the thermal conditions of the working cylinder, and so ensure the maximum efficiency from the fuel burnt within it, diminishing, as a consequence, the heat lost in that operation. Since the maximum efficiency is obtained by combustion of the fuel in the cylinder, and the minimum by the evaporation of the water in the steam generator, it is evident that the larger cooling water form part of the circulating system of a steam generator, which may be an integral part of the engine, or external to it. The cooling water therefore enters and leaves the jacket at a constant temperature, regulated by the pressure of the steam; the cooling being effected by converting the water into steam without raising its temperature. Excluding the radiation losses, which are kept low by lagging, all the heat which passes through the walls is thus usefully recovered in the water as steam. The temperature of the cylinder wall is uniform over the whole of its exterior surface, and the heat lost to the cooling water at each stage of the

cycle—compression, combustion, and expansion —is diminished.

During compression, owing to the walls being at steam temperature, the incoming charge picks up heat, instead of losing it, during the greater part of the stroke, an advantage of the greatest value to the heavy oil types of Still engines, where an air charge is taken in at the full out-stroke, and is compressed to a pressure where its increased temperature ensures the certain ignition and combustion of the fuel which is injected into it.

During combustion and expansion, the uniform and higher mean temperature of the walls reduces the heat lost to the jacket water. Some of the heat thus economised adds to the useful work on the piston, the balance passing out in the exhaust gases for recovery.

To ensure the maintenance, in a practical and reliable manner, of the temperature conditions which produce this efficiency during the combustion cycle, a departure from the design and construction of the cylinders of normal internal-combustion engines is imperative; they have hitherto been made of cast iron, of a thickness sufficient to resist the working and thermal stresses thrown upon them, including occasional heavy loads caused by pre-ignition of the explosive charge. With these thick walls or liners, the temperature difference between their inner and outer surfaces, which is essential if the surplus heat is to be carried off, can only be obtained safely by the circulation of water at low temperature through the jacket; this is especially the case in cylinders of considerable diameter, or capable of high power per swept volume.

The cylinder of a Still engine consists of an inner liner, which is approximately one-third to one-fourth of the usual thickness; it is ribbed externally so as to add to its conducting surface and provide suitable passage for the cooling water, and it is reinforced by an outer hoop capable of withstanding the highest pressures to be met with in working. The stresses due, in ordinary practice, to the cold water at the inlet, and the hotter water at the outlet, are suppressed in the Still cylinder, the cooling water being at a controlled and uniform temperature throughout (Fig. 3).

No failure of a cylinder of any kind has occurred, even under most severe, even abnormal test conditions, *e.g.* with mean combustion pressures of 180 lb. per square inch in a two-stroke engine, to which was added overload steam mean pressures of 70 lb., *i.e.* a total m.e.p. per revolution of 250 lb. per square inch.

Steam from Waste Heat.

In gas and oil engines of constant volume and constant pressure types, the combined losses in radiation—cooling water and exhaust gases—range between 75 per cent. and 65 per cent. The highest indicated thermal efficiency claimed under test conditions with a Diesel engine — Mathot — 300 b.h.p., four-stroke at three-quarter load, is 47 per cent. (36 per cent. brake efficiency). If 4 per cent. is allowed for radiation, 49 per cent. of the total heat is available for recovery, and if 10 per cent. efficiency is assumed for the steam cycle, the brake thermal efficiency of an engine giving this high result would be raised by 10 per cent. of 49 = 4·9, *i.e.* 36 + 4·9 = 41 per cent.; but there is no reason why the steam generated and used

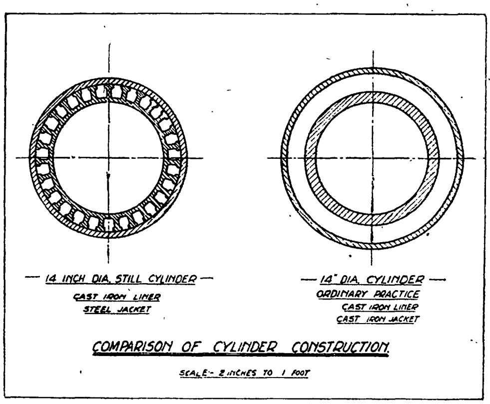


Fig. 3.

under the conditions of the Still system, should be limited to so low a figure. Fifteen per cent. seems a more reasonable assumption, and even a higher figure may be anticipated, in which case a brake thermal efficiency of 44 per cent. should be possible in a complete installation. Such a statement can only be warranted by realising the method by which steam is produced and used in this engine.

Jacket.—The Still engine may be of the constant volume or constant pressure type, or a combination of both; its losses to the cooling water are not the same as in a normal engine of either type, except in so far that they vary with the type, with the cycle, with the efficiency of the combustion stroke, and with the load. At normal and full loads, such heat units, in a Still engine, as pass into the jacket water, which is at steam temperature and pressure, are lessened and are wholly recovered without loss—radiation

excluded—in overcoming the latent heat of the water and give off their steam in the steam space in proportion to the heat flow at those loads. At lower loads less steam is produced, until at still lower loads no steam at all is measurable. In other words, the jacket losses are practically eliminated.

The exhaust gases take a subsidiary, but important part in the cycle; their usefulness in ordinary combustion engines, in raising steam, is limited to the amount of heat recoverable between the initial temperature of the exhaust and that of, say, 50° F. above the steam temperature, after which the whole volume passes away to atmosphere at a still useful temperature, less a small percentage available for feed-water heating. But in the Still engine, the exhaust gases, after raising their quantum of steam, are employed in preheating all the water required for the steam generated in the jacket water and in the generator. Trials at full efficiency over long periods and steady

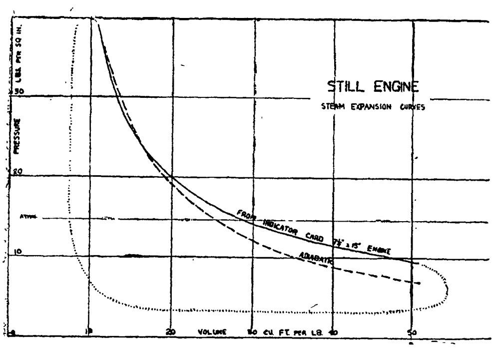


FIG. 4.

loads, show terminal stack temperatures as low as 150° F. The heat efficiency of the combined cycles is therefore exceedingly good, with an initial temperature of over 2,000° F., and a final exhaust to atmosphere at 150° F.

The quantity of steam capable of being generated from "waste heat," depends upon the efficiency of the combustion cycle, and on the load. Some years of experimental work prove that the weight of steam recovered may vary from a maximum of about 7 lb. per b.h.p. hour, developed by the combustion cycle of a four-stroke constant volume engine, at full load, to a minimum at light loads which is hardly measurable, and which only balances the loss due to radiation.

Steam: Use.—The steam thus recovered is a by-product, is limited in amount, and its value depends upon the efficiency of its employment. This is carried out in a logical manner. In place of being expanded in external auxiliary engines, with their thermal and mechanical losses, it is returned to the combustion cylinders of the Still engine, and is expanded on the opposite side of its main piston, one stroke being performed by steam and the other by combustion.

The piston and cylinder walls, pre-heated by the combustion stroke, are at a higher temperature than the steam when it is admitted and while it is being expanded; there is, therefore, no loss from condensation, and the steam exhausts at a slight superheat above the normal expansion temperature, a condition which is unattainable in any form of steam engine without direct loss of energy (Fig. 4). With an early cut off, it can be expanded economically right out to atmospheric pressure, or below it, and be either re-compressed (Stumpf cycle) or exhausted to condenser. The steam, during expansion, forms an efficient means of cooling the piston.

It may be convenient, at this point, to interpolate a few lines on condensing and compounding, either wholly in the Still engine itself, or in external high-pressure cylinders compounding to low-pressure Still cylinders on the same shaft. These separate high pressure and intermediate pressure cylinders will meet special conditions, and have been found of utility where manœuvring or starting in any position is required for single or twin combustion cylinder sets; but a better arrangement in multiple cylinder sets of Still engines is to use the high pressure steam in one of the cylinders at the back of the piston, and compound into similar adjacent cylinders. Many variations of these arrangements suggest themselves. The steam is usually exhausted to a condenser, but it can, in special cases, be employed in low-pressure turbines, or made use of in connection with producer gas auxiliaries.

The effect of the steam in its co-operation with and re-action on the combustion cycle, has been the subject of many series of exhaustive tests, carried out in the early stages of the development of the engine, and subsequently on many other engines, of which the following *résumé* may be of interest.

The engine used for this research was of constant volume type, four-stroke. It first underwent a series of tests, so as to arrive at its "initial horse-power" as an explosion engine, *i.e.* without any power added by the steam cycle, and was carefully checked in this connection by comparison with well-known and authenticated trials carried out by the late

Professor Bertram Hopkinson, F.R.S., and others. Though it was a single cylinder unit with automatic inlet valves, its "initial horse-power" was rated on a par with the power given by four cylinder sets with mechanically operated valves deduced from tests over very short periods, under their best conditions.

The quantity of steam generated per "initial brake horse-power" from the jacket alone, averaged 3·28 lb. per b.h.p. hour, and from the jacket and exhaust together 6 lb. per b.h.p. hour, this being the average of the whole of the trials over periods varying from twenty minutes to over six hours. The final six hours of a seven and a half hours continued test, gave a total recovery of 6·9 lb. of steam per initial b.h.p. A whole series of these early trials was carried out under the supervision of C. Vernon Boys, F.R.S., whose sympathetic interest and encouragement is gratefully acknowledged as having largely contributed to the progress made since the inception of the system.

Detailed figures of these trials would exceed the limit of these notes, but the following *résumé* of the results shows the effect of the interaction of the combustion and steam cycles.

1. The *mean* temperature of the cylinder walls is higher than in ordinary engines; the cooler parts being maintained at a higher, the hotter parts at a lower temperature.

2. The piston is cooler, owing to the expansion of the steam behind it.

3. The heat efficiency of the combustion cycle is augmented owing to the walls being at a higher and constant temperature, and is in proportion to the rise in temperature of the jacket water (*cf.* Hopkinson's trials, Daimler engine).

4. Frictional losses are reduced (*cf.* Hopkinson) by the higher temperature, and by the steam overcoming the inertia of the reciprocating masses at the lower dead centre.*

5. The mechanical efficiency of the whole engine is higher than that obtainable in a normal engine of similar type (*cf.* Hopkinson).

6. The steam, expanding as it does in a cylinder hotter than itself, gives an indicator diagram larger than that theoretically obtainable under ideal conditions in an ordinary steam engine.

7. Twenty-nine per cent. of additional brake-horse-power is added to the shaft of the engine, without increase in the fuel consumption (steam not condensed).

8. Forty per cent. is added with condenser used. (Air pump separately driven.)

9. The i.h.p. due to steam appears as b.h.p. added to the shaft, all the mechanical losses having already been accounted for in measuring the combustion b.h.p.

Normal Load.—The average m.e.p. from the combustion stroke was 90 lb. per square inch. The steam evaporated by the "waste heat" gave 14 lb. per square inch m.e.p. on every return stroke. This is equivalent to 90 + 28 = 118 lb. per square inch m.e.p. in a normal four-stroke engine.

Overload.—By admitting additional steam generated by fuel under the boiler, the steam m.e.p. was raised to 72 lb. per square inch; the total m.e.p. was, therefore, equal to 90 + 144 = 234 lb. per square inch m.e.p. in a normal four-stroke engine.

Gas Engines.

The first experimental engine constructed was a two-stroke engine capable of developing 590 b.h.p. from three cylinders at 400 revolutions, bore 8 in. It was a high speed engine, designed with special regard to obtaining data about the recovery of steam from waste heat (jacket and exhaust). It was first operated on town gas—540 B.Th.U.s, and subsequently converted for oil fuel. Its efficiency was not high, owing to its being a two-stroke engine with a short stroke, but its consumption per b.h.p. was 15 cubic feet per hour (31·3 per cent. efficiency), a very promising result.

The outbreak of war prevented much progress being made in the design and construction of gas engines; but the results achieved give great promise of future development, for with a combustion indicated efficiency of 36 per cent., radiation 4 per cent., boiler loss 10 per cent., there remains 50 per cent. for recovery: allowing 10 per cent. efficiency for the steam cycle, a gain of 5 per cent. is assured, and the total indicated efficiency of the engine will not be less than 41 per cent. If 20 per cent. efficiency is obtained from the steam cycle, as appears possible, the total indicated efficiency will be 46 per cent.

A gas engine which can give a brake thermal efficiency 30 per cent. better than its predecessors, and which, by governor control alone can meet any demand up to and over 100 per cent. overload, while maintaining a good efficiency at that increased output, cannot be neglected.

In November, 1916, at a meeting of the Royal Society of Arts, Sir Dugald Clerk, F.R.S., read a valuable paper in which he alluded to the

* In Professor Hopkinson's trials the frictional loss at 65° F. was nearly double that when the jacket water was at the maximum obtainable, 212° F. In Still's trials, the jacket water was at a constant temperature of 320° F.

important part taken by Britain in the origin and development of steam motive power as being acknowledged as supreme; and he emphasised the leading part, not perhaps adequately recognised, which this country can claim in that great field of invention covered by internal-combustion engines, in which he himself has been, not only a leading contributor, but one to whose work and writings all students of the art and engineers are under deep obligations. In mentioning the attention devoted by German designers to gas and oil engines of large cylinder dimensions, he contrasts the attitude of English engineers by stating that "from the scientific point of view, they consider that the building of large engines, practically without modification of either thermodynamic or operative cycle, is a costly mistake, leading to a development in the wrong direction," and that "other methods must be found of increasing power in internal-combustion engines than mere increase of cylinders and massive construction of engine parts as practised in Germany."

It is true that this country cannot yet claim great installations capable of 80,000 h.p., such as exist at Gary, Indiana, and where they have, with constant reliability and fine efficiency, proved their usefulness; but here, at this crisis, no possible source of cheaper power can be neglected. It is disappointing to read, in the report of the Fuel Research Board formed by the Privy Council Committee for Scientific and Industrial Research, that the gas engine, with its great possibilities and undoubted potentiality for improvement, both thermodynamically and in its operative cycle, is not alluded to; and the only source of power suggested for the countless millions of cubic feet of gas which are now still running to waste, and whose volume will be enormously increased when our coal supplies are more reasonably used, is by burning it under boilers for raising steam.

The thermodynamic cycles and the improved cylinder construction submitted to you, enable more powerful installations to be designed, and promise a substantial increase to their efficiency.

Great improvements have lately been made in gas producers, some of light weight, which answer automatically to all variations of load. The addition of a steam cycle to gas engines, operating with these producers, will give a means of manœuvring and starting which will fit them for service as marine engines and locomotives for road or rail.

Petrol Engines.

Four-stroke engines for petrol and similar fuels have been built and tested ashore and afloat.

The diagram on the screen gives an example of a typical test of a single cylinder engine used for research work. It was fitted with a condenser, and maintained an average vacuum of over 25 in. As the temperature of the whole engine rose to its constant level, the m.e.p. per stroke given by the steam derived only from the "waste heat" gradually rose from 12 lb. to 14·5 lb. per square inch; the fuel consumption (petrol) averaged ·42 lb. over the last four hours; but short period tests under best conditions showed consumptions as low as ·38 lb., with a brake thermal efficiency of 36 per cent. (condenser pump losses not included).

A three cylinder set (marine type) capable of developing, on its three small cylinders at 600 revolutions per minute, 12·5 shaft horse-power at 90 lb. combustion m.e.p., without power from the steam stroke, gave on continuous running, 16½ s.h.p. under "waste heat" conditions, maintaining from the "waste heat" a steady boiler pressure of 100 lb., with sufficient reserve for manœuvring in narrow waters or bringing up. It would pick up very rapidly when ignition recommenced, and bring up the boiler pressure to normal in a few minutes.

With the addition of a burner below the boiler, it would run continuously and develop 38 s.h.p. at 750 revolutions. Momentary overload in proportion to the capacity of the boiler reached 60 i.h.p. (51·5 shaft). Under steam alone the engine is a most satisfactory performer—but not economical.

Oil Engines.

Before describing the use of heavy oils in a Still engine, the two systems now in general use in the so-called semi-Diesel and Diesel engines may be referred to.

The semi-Diesel has been defined as "an internal-combustion engine which has an uncooled portion of the combustion chamber serving to augment the heat generated by the compression pressure, and to assist in the vaporisation and ignition of the fuel injected at the ignition point of the cycle." The fuel is usually injected directly, without air blast, into the cylinder. The majority of them are of two-stroke cycle. The compression pressure is about 185 lb. per square inch. The fuel is injected before the compression stroke is completed, and brings about a rise in pressure and temperature before the expansion stroke

commences. Later development of this type of engine appears to be bringing it nearer to the principles of Dr. Diesel by augmenting the compression pressure to about 300 lb., and so relying more largely on the increased temperature of the compressed air charge and diminishing or even eliminating the specially hot portions or bulbs in the combustion space. This results in a notable increase in the thermal efficiency, and the ability to start up from cold by the primary use of more volatile fuel without the application of external heat. It seems recognised that semi-Diesel engines are gradually approaching the Diesel principle, while the tendency in Diesel practice is towards reducing its initial pressures, and thus approaching that of the semi-Diesel.

The Diesel engine relies for ignition solely on the temperature reached by compression of its air charge. On starting, this is carried out in a cold cylinder with a direct loss of heat to the walls during the whole of the compression stroke. A compression pressure of 500 lb. per square inch is necessitated to overcome this heat loss. This high pressure increases the cost of construction and upkeep, and, since the maximum explosion pressure capable of being reached in a closed vessel may reach six times the pressure contained in it, the whole design and weight of the engine is detrimentally affected; but its brake thermal efficiency of 30 per cent. to 32 per cent., coupled with twenty years of intensive development in all lands, has placed it at the head of all combustion engines in commercial operation which use heavy oils as fuel.

The Still oil engine starts with the cylinders and pistons pre-heated. The air charge, from the moment of its entry into the cylinder, picks up heat from the containing walls and continues to do so during at least 70 per cent. of the compression stroke, with the result that the temperature necessary for firing with certainty the first injected charge of fuel is reached with a compression pressure 50 per cent. less than that required in a Diesel engine.

This fact is far reaching in its importance, for it gives to the designer great elasticity and freedom of application; for a Still heavy oil engine can be designed for constant pressure or constant volume, or both can be employed in the same engine by correct timing of the fuel injection. It claims for its combustion cycle an efficiency higher than that of the Diesel, less weight and space per horse-power, and for its combined cycle an efficiency not less than 20 per cent. higher than any prime mover which uses fuel as its source of heat.

The first engine designed for the use of heavy oil was of the opposed piston type, 16 in. diameter, 32 in. total stroke, revolutions 150, the combustion taking place between the two pistons with the steam generated by the jacket water and exhaust gases expanded at the back of both pistons (the steam passed from the auxiliary boiler through h.p. and i.p. cylinders and finally to the Still engine as an l.p. cylinder), and thence to the condenser.

The steam h.p. and i.p. cylinder was connected to a prolongation of the main shaft at 90 degrees to the main crank; all auxiliaries were separately driven, thermo-couples were connected to all important points in the plant between the combustion space and base of stack. The oil was injected by blast air, scavenge by a fan, pressures from ·5 to 1 lb. per square inch. It was fitted with a brake and fly-wheel of 4¼ tons weight; from full power (300 b.h.p. at 160 revolutions) it will reverse by a single lever from ahead to astern in ten to twelve seconds.

The fact that these engines are capable of running under steam alone, and under constant temperature conditions, gives a facility and security in carrying out preliminary tests and subsequent accurate research which is not possessed by any other combustion engine. All mechanical adjustments, valve setting, degree of compression, temperatures, and so on, can be established at all speeds before any fuel is injected into the main cylinder. This was fully demonstrated in the design and testing of a special engine subsequently constructed to meet special conditions—where the maximum power in minimum space was the main desideratum—conditions not ideal for the highest efficiency.

The dimensions of the cylinder were:—Bore, 13½ in.; stroke, 22 in.; two-stroke cycle, opposed pistons; steam side as for l.p. cylinder. It forms the basis of a six-cylinder set, two of them using h.p. steam, which is compounded into the other four as l.p.

The combustion takes place between the pistons, the steam acting on the return stroke at the back of both pistons. After a series of preliminary tests under steam alone, in which data were obtained for the various mechanical adjustments, the scavenge, compression pressures and temperatures, at various speeds, oil was injected for the first time. The engine fired its first charge without hesitation, and completed a series of tests of over two hours' continuous running, without adjustment, giving an output

by gradually increasing the weight of oil admitted of 100, 150, 200, etc., up to 400 i.h.p., at a maximum speed of 380 revolutions per minute, for which she was designed. The governing of this engine is best demonstrated by the diagram on the screen, which gives a set of cards ranging from 23·5 lb. per square inch to 141 lb. per square inch m.e.p., produced by the combustion cycle alone. This series of cards can be obtained at a constant or varying speed, progressively, from maximum to minimum or *vice versâ*, or from extreme to extreme without any interval.

This unit has been subjected to many long and varied tests by representatives of various Governments, as well as to constant research work under severe conditions. Its best consumption of fuel (Admiralty shale oil) has been as low as ·302 lb. per b.h.p. (scavenge pump not included), over a test of one hour's duration under normal waste heat conditions. It developed 330 b.h.p. for six hours at 360 revolutions per minute (a single cylinder) under waste heat conditions. It will develop 400 b.h.p. continuously with added steam, and has developed 540 b.h.p. at 380 revolutions over short periods. (Combustion m.e.p. 128·2 lb., steam m.e.p. 57·9 lb., total m.e.p. 186·6 lb.) The thermal brake efficiency from below quarter load to full power is maintained at approximately 40 per cent. over the whole range.

With added steam from the boiler, 5,000 b.h.p. would be obtained from two six-cylinder sets, with a weight of about 70 tons, including all auxiliaries and water, and extreme overloads up to 6,000 b.h.p. could be obtained (Figs. 5 and 6).

The application of the Still system to commercial marine work is being developed in this country and abroad; the two-stroke single piston type, in powers of 100 h.p. per cylinder and 400 h.p. per cylinder, having been adopted.

Engines of this type at 120 revolutions per minute, with a cylinder 22 in. diameter by 36 in. stroke, giving 4,200 s.h.p. on two shafts, with all auxiliaries and water, would approximate 600 tons. A geared turbine plant in a similar ship would weigh 20 per cent. more, and would consume approximately 2,000 tons more fuel for a double journey lasting 1,000 hours.

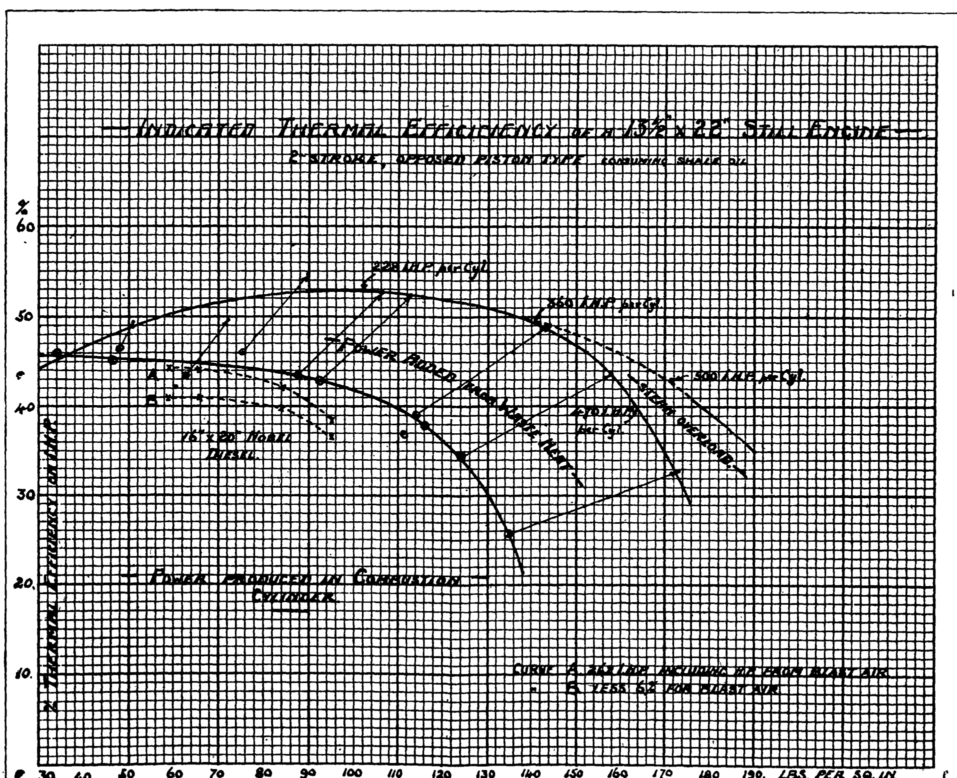


FIG. 5.

Locomotives.

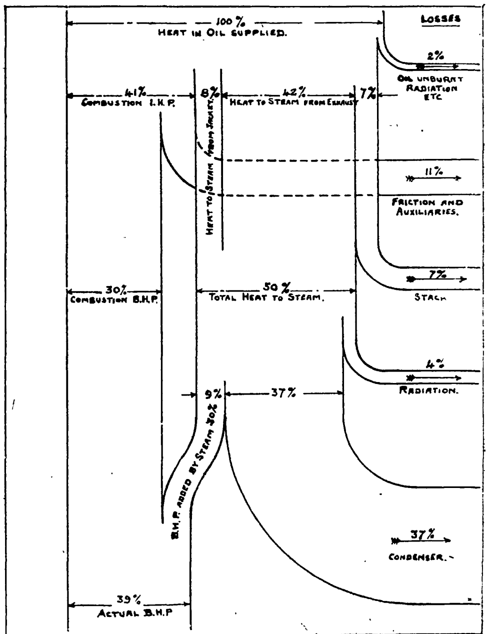
The success already achieved in proving the principles to be correct, both in theory and practice, has led to a careful study, both here and abroad, into the application of this system to locomotive work. No high powered locomotive engine, using heavy oil or gas in its cylinders has been produced capable of economical haulage of heavy loads.

A locomotive is a machine for accelerating a mass, and maintaining that mass at a constant speed. In the present type the best efficiency is attained during the short period of acceleration, say 10 per cent. of its running time, and for 90 per cent. it runs at an efficiency lower than any other steam engine, taking its place at the bottom of the list of heat engines, from a point of view of fuel efficiency. The overall thermal efficiencies may reach 5 per cent. to 6 per cent.: electrification, with steam generation might result in an efficiency of 8 per cent. to 10 per cent.

A Still engine designed for locomotive work would be capable of giving an efficiency at the rails of 30 per cent. over 90 per cent. of its running time—in other words, six times as good as the present locomotive; while during the accelerating period its efficiency would be at least 15 per cent., or three times as good. In surmounting long inclines with heavy loads, the engine would be capable of developing about four times the power which it develops at its most efficient or normal running load.

It is surely not unreasonable to expect that the application of the system here described should be put, without delay, to practical test for locomotive work, and especially so in view of the development and enormous expenditure contemplated in the electrification of railways. To give up the unit system of traction where the failure of one unit does not involve the failure of the whole, and to rely on what is, after all, a delicate and easily dislocated source of energy from central power-stations, merely to gain a problematical 6 per cent. increase of fuel efficiency, seems to involve a risk far greater than the encouragement and development of novel forms of engines, which, whether gas or oil, may be evolved at the present rate of progress before the country is too far committed to such a gigantic and possibly dangerous experiment.

Sufficient evidence has, it is hoped, now been given to show that, from the points of view of science and of practice, there is a great future before the combination of the steam and combustion cycles. From the theoretical side the possibilities of the combined cycle can be realised by the diagram on the screen, which shows the (*a*) ideal cycle at the high temperatures and pressures realisable by the combustion of fuel within the cylinder, and (*b*) that of the steam capable of being raised by the heat rejected in that operation—the one in accordance with the air standard of the Committee of the Institute of Civil Engineers, adapted to the combustion cycle (partly at constant volume and partly at constant pressure), as used in the Still heavy oil engine, and the other by the Rankine method. The two together give an ideal thermal efficiency of 67·8 per cent. That a two-stroke high speed



13·5"x22"

— Still Engine Heat Balance —

Fig. 6.

engine of an early type, not designed specially for efficiency, should already have reached an actual indicated efficiency of 47 per cent., that is to say, an efficiency ratio of 70 per cent., warrants the assurance that still higher efficiencies will be obtained in later designs, where full advantage is taken of lessons already learned with regard to clearances, compounding, and so on, which are being embodied in designs now under construction.

But science and practice, like capital and labour, must work hand in hand. It is satisfactory, therefore, to state that in practice the Still engine can claim that it has carried out completely the objects of its inventor, and has

corroborated and confirmed the principles on which he has worked.

These may be summarised as follows:—

1. The higher mean temperature of the engine makes the combustion cycle more effective and more reliable in starting and in running.

2. The mechanical stresses due to heat are reduced.

3. The steam generated by the heat rejected by the combustion cycle augments the power of the engine without increasing the consumption of fuel.

4. The steam generated by the heat rejected by the combustion cycle cools the piston.

5. The steam generated by the heat rejected by the combustion cycle reduces the mechanical losses of the engine.

6. The steam generated by the heat rejected by the combustion cycle is used under exceptionally favourable conditions, since it absorbs heat during expansion.

7. The steam generated by the heat rejected by the combustion cycle suffers no condensation loss in the working cylinder.

8. The steam generated by the heat rejected by the combustion cycle warms the engine before starting, so that no sudden temperature changes occur in any part.

9. The steam generated by the heat rejected by the combustion cycle starts the engine against load if necessary.

10. The steam generated by the heat rejected by the combustion cycle enables manœuvring at any speed from nothing to maximum and for any period.

11. Starting is unaffected by atmospheric conditions.

12. Power at normal loads is developed by combustion and steam from waste heat alone, with an efficiency at least 25 per cent. above any known combustion engine of similar proportions.

13. Since the steam raised by the waste heat is more than enough to overcome the mechanical losses of the engine, the b.h.p. of the engine is at least equal to the i.h.p. produced by the combustion stroke.

14. Additional steam gives a large range of overload without serious loss in efficiency.

15. In engines using heavy oil as fuel, the compression pressures which ensure the ignition can be reduced by 50 per cent., as compared with the Diesel system.

The internal-combustion engine, during the present generation, has achieved an astounding success under conditions less favourable than those which are here presented; installations developing thousands of horse-power ashore and afloat, and beneath the sea, have been placed at the service of man. Fifty years of devoted science and practical skill have brought it to its present state of serviceability. If the Still engine, in its infancy, has been able to show, in spite of the limitations of its upbringing, improvement in the thermal conditions, balance, torque, manœuvring power, overload and fuel consumption, with less weight and space for the power it develops, it can look forward with some confidence, now that it can pass through the severe school of the engine shops of the world, to an adolescence of great promise, and it would be unwise to say what may be the limit of its ultimate career.

The following passage occurs in the final chapter of "The Gas, Petrol, and Oil Engine," 1916, Vol. II., by Sir Dugald Clerk, F.R.S.:—

"There appears to be only one method open to further increase thermal efficiency in a practical way, and that is by using regeneration of heat in some form. The utilisation of the waste heat of the water-jacket and the heat of the exhaust gases to raise steam has become considerable. It has been already mentioned that about 2·5 lb. of steam per b.h.p. has been obtained from the exhaust gas heat of large gas engines. Taking 10 lb. of steam per shaft h.p. as the consumption of a high efficiency Parsons steam turbine, this would add 25 per cent. to the power of the gas engine without burning any more fuel. A brake thermal efficiency of 30 per cent. would thus be raised to 37·5 per cent.

"With an engine giving so high an indicated efficiency as 40 per cent., the exhaust heat would be insufficient in amount to raise 2·5 lb. of steam per b.h.p., but if all the waste heat were collected from the jacket, piston, valves, and exhaust—amounting to 60 per cent. of the original heat—then the 40 per cent. would be increased to nearly 50 per cent. on the assumption that the heat could be utilised in a highly efficient steam turbine. The combined brake thermal efficiency of such a regenerative gas engine would be about 43 per cent."

This is the method which has now been presented before this Society. It pretends to be merely a condensed summary of many years of patient, arduous work, combined with an admirable audacity without departure from the recognised laws of thermodynamics by William Joseph Still. Confirmation by so high an authority as Sir Dugald Clerk that this appears to be the only "method open to further increase thermal efficiency in a practical way," forms a fitting ending to these notes.

The author of this paper, who has had the

privilege of being associated closely with Mr. Still from the first inception of this work, cannot conclude without an expression, on behalf of them both, of the most grateful acknowledgment to the very large number of individual scientists and engineers, not only in this country, but among our Allies in the great war, for their encouragement and support during the past years. These include representatives of their Governments, of various scientific bodies here, in France, the U.S.A., and Japan; but especially we record our sense of deep obligation to Messrs. Denny, of Dumbarton, Messrs. Scott's Shipbuilding and Engineering Co., of Greenock, Messrs. Armstrong, Whitworth and Co., and the British Admiralty; to C. Vernon Boys, F.R.S., and the late Lieut.-Colonel Dr. Watson, F.R.S., whose death is deeply deplored.

DISCUSSION.

Sir Dugald Clerk, K.B.E., F.R.S., stated that he had had the pleasure two years ago of inspecting the engines of which photographs had been shown on the screen, and he had for a very long time indeed seen that one of the methods of increasing efficiency was to use steam raised by waste heat. The author had read that afternoon a part of the final chapter of his (Sir Dugald's) book. That chapter had been written in 1912, and it contained his discussion of the possible methods of obtaining an addition to the thermal efficiency of gas engines. Many experiments had been made on the variation of compression volume—compression space—and the limit seemed to have been approached. Up to a compression ratio of 14 or 20, the ideal thermal efficiency, the air standard efficiency, as it was called, rapidly rose; but after 20 the curve became very flat, and practically no further good could be obtained by increasing compression above 20. As a matter of fact, no engines had ever yet been run which had used a compression of 20. The Diesel used from 12 to 14. That was, the ratio of compression space to the total volume of cylinder swept by piston plus compression space was from 12 to 14. At about 20 ratio the compression, the ideal efficiency—that was, of the air standard cycle, if air standard was being dealt with—was ·7. As the result of practice in an ordinary well-designed internal-combustion engine, either Diesel or constant volume engine, it was always found that, with properly designed valves and a properly designed combustion space with a minimum of port surface or no ports at all, one could reckon on getting ·7 of the air standard efficiency in indicated power in the engine; that was, if one had an engine with about 20 range of compression one could get an actual indicated efficiency of about 49 per cent. In a book which had been written by himself in 1885* he described and criticised an engine containing a combined steam and gas system. It was the Simon engine, built by Simon of Nottingham, exhibited at the Royal Agricultural Show in Bristol in 1878. In that engine all the jacket heat and all the exhaust heat had been used to raise steam in a small separate boiler which had been attached to the engine; but instead of being used in a separate cylinder, or in a separate part of the combustion cylinder, it was thrown in with the flame, and the consequence had been that the efficiency of the engine had not materially benefited. Writing at the end of 1885 he had said about that engine: "Messrs. Simon, of Nottingham, introduced a Brayton engine to England in a slightly altered form as a gas engine. In addition to the ordinary arrangements of the engine, they attempted to gain increased economy by causing the waste heat passing into the water-jacket, and the heat of the exhaust gases, to be utilised in raising steam. They would undoubtedly have increased the economy of the engine in this manner had they not turned the steam so raised into the motor cylinder along with the flame." Then he had described the boiler, pump, and so on, and stated: "With a suitable arrangement, using steam in a separate cylinder, doubtless 6 per cent. might be added to the indicated efficiency of the engine, but it is very questionable whether the increased complexity does not entirely destroy any advantage gained. It certainly does so in small engines, but when very large engines come to be constructed the complexity would not be so great, and it would be worth while to use the waste heat in steam-raising." Many gas engineers had been using steam in various ways. At the National Gas Engine Company's works a number of engines had been built for the Castner Kellner Company at Runcorn many years ago, which had been fitted with exhaust gas boilers. Those engines had been running under ideal conditions for utilising the exhaust gas, as they had been operating an electrolytic plant at practically full load all the time. Indeed, one of the engines had run for six months night and day without stopping. The consequence had been that there was no question of a weak mixture, or few ignitions or a very small heat flow through the jacket. The maximum heat flow through the jacket and the maximum heat of exhaust had been always given. In those engines had been found about 2½ lb. of steam per brake horse in the boilers generated at about 100 lb. pressure. It would be gathered from what he had said that the idea of using steam in addition to internal combustion had long been in the minds of engineers. When he had been continuously

* Pages 163–4, "The Gas Engine," by Dugald Clerk. Longmans, Green & Co.: London, 1886.

engaged on experimental work, from 1876 till about 1888 or 1889, it had been very commonly in the minds of engineers, and he had thought it out very carefully. It had been soon found that there was a great field to be worked in studying the ordinary theory of the engine and increasing the efficiencies without requiring any additional gear. To the year 1882 the indicated thermal efficiency of the best four-stroke engines had been only 16 per cent. The compression had been low, and there had been a false theory as to the cause of economy which had prevented many engineers from trying increased compressions. Since that time, from between about 1882 to about 1908, the efficiency of an ordinary internal-combustion engine had risen from 16 indicated to 35 indicated; 35 had been the figure in the tests which had been made by the Institution of Civil Engineers Committee at the National Gas Engine Company's works. Since then there had been even higher efficiencies claimed. He noticed that the Diesel four-stroke engine test by Mr. Mathot was given on the author's table as 36 per cent. brake efficiency. That efficiency was by no means confined to that large engine. In the ordinary smaller types of Diesel engine, now so largely used in submarine work with solid fuel injection, efficiencies rather exceeding 36 per cent. had been obtained regularly during the last few years. One reason, of course, was that in those engines they had numerous cylinders; it was not a one-cylinder engine, and the mechanical efficiency of the combination was high, but he was not satisfied that the author's claim, 25 per cent., was yet justified. He quite agreed that one ought to be able to get 25 per cent. more of the brake power by a judicious use of steam, although he figured in his mind the use of large engines and the highest efficiency which Sir Charles Parsons' turbines could have given. With that he could have done it, but he doubted whether an engine of the type shown by the author on the screen, with the long sleeve and the clearances that there must be there, could be expected to give efficiencies approaching what he had been mentioning—namely, efficiencies of about 20 per cent. additional. He noticed that the author said there was nothing to hinder the steam side giving an efficiency of 15 per cent. of the steam heat. He (the speaker) had gone through the paper very carefully, and it would be very interesting if the author, in publishing the paper, would add a few tables showing the actual thermal efficiency of the steam side as determined by his tests. He noticed that the highest efficiency the author claimed for the Still engine was about 41 per cent. brake efficiency. Was that the efficiency including the steam evaporated by waste heat? Was that the total efficiency without any added steam?

Captain Acland replied in the affirmative, and said that added steam lowered the efficiency, of course.

Sir Dugald Clerk said he knew that, and he desired to ask on that point, with an engine giving 41 per cent. efficiency of the type spoken of by the author, would one get cooling enough for the pistons to run continuously, without water in the pistons, by the steam added to raise the efficiency, say, from 36 per cent. to 41 per cent.? He could quite see that, in addition to the thermal question, there was the practical one of the locomotive. It was quite obvious that a compound steam and internal-combustion engine would be a very handy piece of apparatus, and there were certain advantages to be gained, no doubt, from the heating of the cylinder. It made it more easy to ignite, and the compression ratio need not be so great, when one could ignite with certainty without such a large compression ratio in the type of Diesel engine. Of course, it should be pointed out, that if one reduced the compression ratio in the Diesel engine, one also reduced the thermal efficiency pretty rapidly, and nothing in the way of heating by the jacket could help that. With regard to the second point mentioned at the end of the paper, he did not think it could be said, from the author's experiments, that the mechanical stresses, due to the heat flow, were really reduced. The mechanical stresses found in the internal-combustion engine, within the cylinder and within the combustion space and piston, were not those due to the difference of temperature between the cold water jacket and the hot water outlet. They were due to the cyclic change within the cylinder, because of the fact that one instant there was a flame playing on a piece of metal with a temperature of nearly 2000° C., and the next instant there was part of the cold air playing on the same plate of metal. The consequence was, there were obtained expansion stresses which had nothing to do with the water-jacket system at all. He did not think the steam would do any harm, but it would not do any good from that point of view. That kind of trouble was not found in small cylinder engines, and so far the author and his friends had only been working with small cylinders. With regard to No. 12, "Power at normal loads," he agreed that with a sufficiently efficient steam engine one would be able to get the 25 per cent. He did not think the author claimed the 25 per cent. at present. In the diagrams there was not 25 per cent. between, for instance, 36 and 41. There was no doubt that one could add very materially, and he thought the larger the engine the better the author's and Mr. Still's chance. It was part of the characteristic of our race, that those two gentlemen should have experimented for years on a very difficult subject, and inch by inch should have mastered

it. He had no doubt that, with experience, they would be able to deal even with the larger cylinders up to 20 in. and perhaps 30 in.

CAPTAIN ACLAND said that they were up to 22 in. at the present time.

SIR DUGALD CLERK said he had no doubt that they would obtain the efficiencies he had been mentioning. There were other ways of regenerating, but steam seemed to him the most practical at present.

PROFESSOR W. H. WATKINSON remarked that he had had the pleasure, about a year ago, of seeing one of the engines at work at Chiswick, when he had been very greatly impressed by the ease with which it could be manœuvred. Its power could be varied from zero up to an overload within a few seconds; but what had impressed him even more than the engine, had been the exceedingly delightful modesty of its inventor, Mr. Still. He would like to ask a question as to the kind of lubricant used to enable the piston to work under the high temperature conditions. Then there was a point regarding the possible destruction, or reduction at any rate, of the vacuum due to leakage past the piston. Leakage sooner or later would occur, and that, with the arrangement shown, must involve a great reduction of vacuum and a greatly increased amount of the work to be done by the air pump. Had any difficulty of that kind been met with? Sir Dugald Clerk had raised the point as to whether steam cooling would suffice for much larger cylinders than those which had been experimented with. His (the speaker's) impression was that steam cooling would not suffice, and he believed that it would be well that that arrangement of having steam cooling, using the steam on one side of the piston, and internal combustion on the other side; should be departed from, and that the steam should be used in, say, the uni-flow type of engine, or in one of the Parson's steam turbines. He believed, in either of those ways, a more practical engine for big scale work could be obtained than with the combination shown. Then the author had mentioned experiments with gas and petrol engines. He (the speaker) should have anticipated that, owing to the heating of the charge during its admission and during its compression by the heat transmitted from the hot water in the jacket, pre-ignition would inevitably have occurred both with gas engines and with petrol engines. He thought that would be the case if fairly large engines were used. If the cylinders were only a few inches in diameter, possibly there was no difficulty of that kind, but he imagined there must be a difficulty in big engines. The author had mentioned an oil consumption of ·302 lb. per shaft horse-power hour. It was exceedingly difficult to accept that figure as being a figure obtained during a regular run over a sufficient period. It might be a snap result, but he thought it was too good to be obtained in regular working over several hours. Possibly the author might be able to state whether it was the result of a long run or not. If it was, even in spite of the great complexity of the engine, there must be a very great future for it. Another point was as to the lower limit of power which the author considered suitable for the engine, which must be complex in any case, because it added to the complexities of the internal-combustion engine all the complexities of a condensing steam engine; and one would imagine that there must be some lower limit of power, especially for marine purposes, and it would be interesting to know what the author's estimate was of that lower limit.

PROFESSOR C. VERNON BOYS, F.R.S., said he had been privileged some years ago to conduct some tests on the engine as Mr. Still had been developing it from the beginning, and he should like to say how he had been struck with the perfectly scientific manner in which Mr. Still had arranged the series of tests with a view to the determination one at a time of the value of each individual step. So the tests had gone on, and the engine had developed. Then with the war there had been a most serious and disastrous interruption of steady and regular progress, but in spite of it all the work had been carried through to what must be recognised by everyone as a most remarkable and valuable success. These tests showed conclusively the value of the Still combination. The steam on one side of the piston and the explosion stroke on the other side of the piston did not act disastrously as in the case which Sir Dugald Clerk had mentioned, where the two were put in on one side. By a miracle of good chance, or of genius on the part of Mr. Still for foreseeing it, the steam on the one side of the piston enabled the explosion operation on the other side of the piston to do better than it did previously. The explosion operations on the other side of the piston put the steam in the engine into a position not found in any engine before, and instead of having condensation and loss and waste and all the things that went to damage the perfection of the steam engine, the steam picked up heat and did better than it could even in a theoretical engine. That was a happy combination, and that was only one advantageous pair of circumstances which had resulted from the Still combination. Practical men knew the importance of keeping down stresses, more especially when very large engines were made. He had heard practical men speak with some degree of fear of the heavy stresses set up in Diesel engines, and he believed that

accidents had taken place. It was something to retain or improve the efficiency and keep those stresses down to a much lower degree. He would like to correct a misapprehension which he thought Sir Dugald Clerk was under with regard to the stresses set up due to the thermal differences in the engine as compared with one into which cold water was fed into the jacket of a cylinder going out hot. He was not quite sure whether Sir Dugald stated that the warming of the water gave rise to the trouble. He (the speaker) thought that in the Still type of cylinder the mechanical stresses set up were less. That was because the thickness of the wall space between the hot gases inside the cylinder and the circulating water was not the thickness of a cylinder which was strong enough to carry the pressure; it was a relatively thin casting between the inner wall of the cylinder and the series of water spaces, and that did not take the explosion stress which was borne by a jacket outside it. So that stresses set up in the cylinder by the gradient of temperature between the interior and the exterior were taking place in metal which was of a form more able to withstand them, because at least it was free from the bursting strain of an ordinary cylinder, and there was less stress to withstand. In conclusion, he desired to refer to the present universal panacea of world-wide electrification. The newspaper view of it, that of br'nging hot water to every cottage and so on was, of course, all rubbish. Surely there was too much being promised about universal electrification, and a paper of the sort read that afternoon might go a long way towards an appreciation of what is possible.

Mr. J. B. Stokes said, with all due deference to Sir Dugald Clerk, who had gone into the past history of gas engines, he really thought that it was the future which concerned those present. The opportunity was at hand, and there was no time to be lost. The Bill for the supply of electrical power on a national scale was before Parliament, and the question he would put, not to the author, but to the audience was: "What are you going to do about this business?" Were they sufficiently interested, and was their faith in the engine such that they considered it worth while continuing further research work on a large scale? If they thought that, then he would urge them to do what he had done that morning. He had gone to the Houses of Parliament, had met his representative, and had asked him whether he was prepared to back up a full inquiry being made into all types of prime movers before the Government finally settled upon the best one to adopt. He thought the audience should get their representatives to do the same. He was glad the author had brought forward the point of locomotive engines, because he thought that that was the line along which the first great development would lie. One of the speakers had referred to the trouble of designing the particular engine under discussion with larger pistons, but there were ways of getting over that trouble besides going in for larger pistons—namely, by multiplying the number of pistons. For instance, some aeroplane engines had about thirty-six cylinders. He had no doubt that, at any rate, twelve cylinders of the size that the author had suggested, 22 in. by 36 in., could be utilised quite well, and would develop a very large quantity of power; but the point was that in locomotive work there was already a size of cylinder which was suitable for the type of engine mentioned, and he would suggest that, to enable the locomotive to start readily from any point, arrangements might be made by which steam could be admitted, not only to the regular steam ends, but also to the combustion space. He would throw out one further point for what it might be worth. It would be noticed that one of the drawbacks of the engine was the number of auxiliaries about it. For instance, there was the blower or blast fan. The multi-type of steam ejector had been successfully adopted in practice for sucking air out of a vessel. Why should not the same system be adopted for pushing air into the vessel, and by that means save one complexity of motor, fan, etc.?

Mr. Frank Bailey understood that the size of the generators must necessarily be governed by the limitations of the system so far as the size of cylinder was concerned, and therefore power above a certain limit could only be obtained by increasing the number of cylinders, and, therefore, the number of lines of moving parts. He did not say that was a disadvantage for a moderate output, but, so far as electrical supply was concerned, it opened an interesting feature. It was not now a question of the engine being in competition with the steam turbine, so much as it might affect the demand on the electrical power works by the ability of power users to utilise a more efficient generator. All the claims regarding the future efficiency, and the future improvement of public electrical supply, were more or less based on the improvement of the load factor. If that load factor was to be materially influenced in the future by the development of a better type of prime mover, clearly it would pay many users, who were now glad to use the electric motor, to put in power of a limited size but sufficient for their own supply. He thought in that way it must be realised that the paper and the scheme put before the audience that afternoon, with the success already obtained, had a very vital bearing on the matter, especially in developing small generating works in those areas which would otherwise require costly transmission mains from a distant source. If the paper could do anything towards opening the eyes of the British public to the dangers which confronted them by the super-

enthusiasm of some of our legislators, it would not have been read in vain.

MR. F. LEIGH MARTINEAU said he had had the pleasure of following the engine from the beginning, and he thought it might interest the audience to see the figures which would result from what one might call the "De-Stilling" of the best Diesel engine given in the Table (Fig. 1), which gave a brake thermal efficiency of 36 per cent., and an indicated thermal efficiency of 47½ per cent. If the same type of engine was converted or rebuilt, so as to adopt the Still principles, the following results would be obtained. The indicated thermal efficiency was 47½ per cent., and the brake thermal efficiency was 36 per cent., so that there was a friction loss of 11½ per cent. The total waste heat was 52½ per cent. The radiation loss would be about 2½ per cent., and the stack loss 8 per cent.; so that the waste heat available as steam, which gave a boiler efficiency of 80 per cent., would be 42 per cent. Using compound on the steam side with the superheating during expansion, there was no reason, as far as could be seen from the experiments already made, why there should not be 20 per cent. available from the actual steam used in the cylinder as indicated power. Therefore 8·4 per cent. would be added in efficiency to the 36 per cent., which would increase the brake thermal efficiency up to 44·4 per cent., and the indicated thermal efficiency up to 55·9 per cent., or an increase of efficiency of 23½ per cent. on the brake. These figures do not take into consideration one or two small gains which actually occur in practice. No decrease of friction was allowed for, and the friction of a Still engine was always less than that of a normal engine of the same size. Again, certain other friction losses, although they were present in the engine, actually gave back a certain percentage of their friction heat as steam. For instance, piston-ring friction created steam in the jacket, or helped to do so.

MR. W. J. STILL, dealing with the question of lubrication which had been raised in the discussion, said he had gone into a long series of experiments on that point before building any engine. He had made some trials with a shaft heated to a temperature such as he expected to run at, and also in contact with flame, and he had found that if the temperature rose to about 450° F. difficulties began; but below that point perfectly good lubrication was obtained under very heavy loads in the cylinder with a mixture of heavy cylinder oil and graphite. His experiments with the engines when they were built had substantiated that position. He had never had any trouble whatever in regard to lubrication. In fact, he was using much less lubrication than was used on ordinary combustion engines. A set of trials made for a certain Government, gave a consumption of lubricant equal to 1·4 per cent. of the amount of fuel oil used in the combustion cylinder. Better results even than that had been obtained, but that result had been obtained over long trials at three-quarter load, which was not, of course, the most efficient condition so far as lubrication was concerned. During that trial the engine's mechanical efficiency was 87 per cent., and after the run the engine was examined very carefully, and the surfaces were found to be in absolutely good condition. The engine had also been run for a very long period before those trials under the same conditions of lubrication. As to "complexity," it should be borne in mind that the engine is not a prime mover with parts added to it, but two prime movers both earning dividends. With regard to complication, combined engine installations often contained less parts than direct-combustion engine equipments required to perform the same duties. Such a subject could not be dealt with properly within the limits of the discussion, because each application of the engine must be dealt with separately; but, considering one type only, viz., large marine Diesel installations, these would be found usually to contain more parts, and those of a more troublesome character, than were essential to a Still engine equipment. It was, for instance, a matter of common knowledge that large Diesel engines were often constructed with piston rods and crossheads, in order to obtain better running conditions, and all Diesels were fitted with air-starting valves. The latter were equivalent to the steam valves of a Still engine, so that the only added gear the engine contained was a cover and stuffing box for each cylinder; these were not moving parts, and a well-known firm of Diesel engine builders fitted their engines with these parts merely to avoid chilling the combustion chamber with compressed air when manœuvring. The large business carried on by this firm indicated that the added parts justified their existence although their use was momentary and they added no power to the engine equipment. The Still engines were therefore, in themselves, as simple as these Diesels, and the steam parts were in continuous operation as prime movers, and were thus capable of earning dividends upon the capital expended in their production. With regard to the auxiliaries, in the combined system these consisted of a boiler fitted with an oil burner and feed pump, also of a condenser and its air and circulating pumps. The boiler, burner, and feed pump were usually to be found installed with Diesel engines merely for cooking and heating purposes, but these engines also required at least one set of large auxiliary engines attached to air compressors of equal power, and were often fitted with two such sets. In addition to these, they required compressed air receivers

and cooling water pumps, with, in recent systems, a water-cooling element (practically a condenser) for cooling the fresh water used in the cylinders, and a circulating pump for passing salt water through its tubes. It was certain from the foregoing that many large Diesel installations contained far more parts than those necessary for a Still engine, and even the simplest of them were more complicated. Most of the Diesel auxiliaries consisted also of very fine high class machinery, which required far more attention and upkeep than steam auxiliaries; the functions they fulfilled were also non-remunerative, and the fuel consumed in them when "standing by" was wasted. With regard to the question of stress caused by cyclical change of temperature in cylinder walls, the speaker called attention to trials conducted by Messrs. Coker and Scoble (*Proc. Inst. of Civil Eng.*, session 1913–14), during which this was found to amount to only 9·3° C. at a depth of ·015 in. from the surface of the combustion chamber of a four-stroke gas engine. In respect of comparisons of thermal efficiencies these should be confined to such engines as were of similar size, and work on like cycles; the 41 per cent. quoted by Sir Dugald Clerk was obtained from a high-speed Still engine operating on a two-stroke cycle, and was not properly comparable with the engine tested by Mr. Mathot, which was a slow-speed engine working on a four-stroke cycle. As illustrating the different purposes for which these engines were designed, it might be noted that this Still engine gave in normal service four times the output per square foot of cylinder cross-section obtained from this particular Diesel; it must not therefore be expected also to add 25 per cent. to the heat efficiency of this exceptionally efficient engine. That it did add 14 per cent. was sufficiently remarkable. If, however, this high speed two-stroke engine was compared with Diesels of a similar class, such as the Nobel Diesel, the trials of which were reported in *Engineering* in September 1915, it would be seen that although it gave twice the output per cylinder cross-section, it also added 38 per cent. to the thermal efficiency of that engine as tested at full power, and 27 per cent. to its best efficiency; at the latter load the Nobel gave less than one-third of the relative power output of the Still engine.

THE CHAIRMAN (Sir C. A. Parsons) inquired what was the maximum steam pressure which Mr. Still had tried? What was the maximum temperature to which they had allowed the water in the jacket to reach? It depended on the steam pressure. In steam engines, and especially in large generating centres in the north of England, they were going up to 400 lb. pressure, and that meant a very high temperature. He had been wondering whether that high temperature would affect the lubrication of the internal-combustion engine adversely.

MR. STILL said they had worked up to 250 lb. to the square inch.

THE CHAIRMAN, continuing, said he agreed with Professor Watkinson that in a system with a large number of gas engines he would rather take the combined steam direct into the turbine, if a turbine was to be used. One wanted the highest possible vacuum, and it would not do to have one high-pressure cylinder with a reciprocated piston, because it would admit gas to the steam side and that would partly vitiate the vacuum; so he thought in a large system he would prefer to keep the steam entirely separate from the gas. But, of course, as other speakers had said, for engines of moderate size it made a very convenient unit, and was much simpler than the separate steam engine. It might be of interest if he stated that, before the war, designs had been got out to apply combustion engines to a cruiser of 30,000 h.p., and it had worked out to 150 cylinders all geared on to four screw-shafts. They covered nearly the whole bottom of the ship. The only way to get a large power on to an alternator or dynamo was to gear a number of internal-combustion engines through frictional spring couplings, on to, say, one reasonably large sized generator. One got a cheaper and more reliable engine by keeping the size of the unit small, and also a less total weight. He looked forward to a great future for the gas-steam engine for locomotive work. The internal-combustion engine by itself would not take overload for starting and stopping and varying output, as had been fully described in the paper. He thought, especially in waterless districts, like Australia, there ought to be a very great future for it. He believed that a certain number of internal-combustion locomotives had been already built for Australia.

CAPTAIN ACLAND said, in view of the lateness of the hour, he would communicate his reply in writing.

CAPTAIN ACLAND'S reply is as follows:—Sir Dugald Clerk draws attention to the increase of ideal efficiency with increase of compression. This increases the upper limit of the temperature scale as well as the pressure, and necessitates heavier engines with greater mechanical and heat losses: the gain in useful or brake efficiency is small, if any, and so engines with high compression ratios remain ideal like their efficiencies. The Still cycle is quite logical in that it deals with the lower limit of the temperature scale and increases the brake

efficiency in a practical manner. With regard to the sizes of engines possible with this system, the principles set out in this paper are admitted by Sir Dugald Clerk as correct; the internal-combustion engine should therefore have a new lease of life, and engineers find many difficulties, which they have hitherto encountered, removed. The percentage of heat passing to the cylinder walls and pistons is found to be less than in normal engines, and the cooling of larger pistons can therefore be carried out successfully with the quantity of steam available. To use the steam in turbines or external engines, as Professor Watkinson and others suggest, is possible, but implies loss of efficiency, both in the combustion and steam cycles. Details which depend on the specific application of the system have been avoided as much as possible in a paper whose object was to submit for examination and discussion the principles of a new prime mover. The best consumption of ·302 lb. per b.h.p. hour was over an observed period of one hour after the engine had been run continuously to obtain steady conditions. The special construction adopted with a view to meeting the anticipated difficulty of maintaining an efficient vacuum has proved effective. The author desires to thank all those who were kind enough to take part in the discussion, and to record that Mr. Still, after many years of close study and research on heat transmission, submitted the whole of the basic principles on which he intended to work to Professor C. Vernon Boys, F.R.S., in 1909.

LIEUT.-COLONEL D. J. SMITH writes:—The ever-increasing cost of coal has compelled engineers to search for some means of using it more economically when it is used for the generation of power. This cost is not likely to decrease; in fact, if it can only be decreased by giving insufficient remuneration to the miners, it should not even be considered; for although many criticisms have been levelled at the high wages of the miners, there does not appear any great competition for jobs in coal mines by those making the criticism. If the increased cost of coal is the means of bringing any new device into service which will do the same work on a lower consumption, it will be an unmixed blessing, for the prodigal way in which this, our greatest asset, has been wasted up to the present time is a scandal. Many attempts have been made to recover some of the heat lost in the working of steam and internal-combustion engines, such as using the exhaust of the steam engine to furnish heat to a boiler containing some fluid of low boiling-point, *e.g.* ether, etc., the vapour generated being used in another engine. The exhaust of internal-combustion engines has been made use of for the same purpose, as also has the cylinder jacket. In all these attempts, however, the bad points, if I may term them so, of each form of engine have remained untouched, and it is to Mr. Still that we owe this great improvement whereby the weak points of each cycle are used to advantage by the other. So far, for high powers, the steam turbine has things all its own way, but it is doubtful if this can continue if the promise of the Still engine is fully borne out, and it will be very remarkable if in marine practice a return is made to reciprocating machinery for large powers. That this seems very probable is due to another factor which the author mentions, viz., the great improvements recently made in gas producers. Gas producers would make an almost ideal combination with the Still engine, and would furnish power at a fuel expenditure hitherto considered impossible, for in this also the weak points of both the Still engine and gas producers will marry up and produce higher efficiency. The high cost of fuel is a great handicap to the most easily handled and controlled form of power we have, electricity. The extreme advantages possessed by electricity are such that they almost counterbalance high cost; but if it is possible, as it appears to be, to generate electricity by the Still engine and improved gas producers at a much lower cost than is now possible, it will be a great boon and give an enormous impetus to electrical development in every direction. The figures given by the author from the report of the Coal Conservation Committee are not very helpful. Even after spending millions in building vast central stations, it is only expected to reduce coal consumption per h.p. to 1·5 lb. As this figure can be greatly improved upon now in any small generating plant using a good gas engine, it is hard to see where the coal conservation comes in, while as to the money conservation, well, if these great stations are run under State control, we all know what to expect. Sir Dugald Clerk has plainly shown that the present method of using electricity for power and heat is vastly wasteful of coal. If we are to be forced to use electricity for these purposes in order to justify enormous State controlled electric generating stations, it is to be hoped that the Still engine will be fully investigated before the plants are ordered, as waste of coal means far more than waste of money, and there exist now millions of tons of so-called waste fuel which could not be used under steam boilers, is almost useless for ordinary gas production or the recovery of by-products, but which could be successfully used in certain new gas producers, and, in conjunction with the Still engine, would use the nation's resources to far greater advantage, which is the thing that counts far above cost.

MR. F. LEIGH MARTINEAU writes:—As it may be of interest in the discussion of the Still engine to have the figures recorded which I quoted, I enclose

herewith, the table which I showed on the screen:—

TRIALS OF A 300 H.P. DIESEL, FOUR-STROKE, ENGINE, CONDUCTED BY MR. R. E. MATHOT.

Engine cylinder 14·2 diameter by 26·77 stroke	182 r.p.m.
Indicated thermal efficiency	47·5 per cent.
Brake thermal efficiency	36·0 „
Friction loss	11·5 „
Total waste heat	52·5 „
If designed as Still engine the result would be:—	
Radiation loss	2·5 per cent.
Stack loss	8·0 „
Waste heat available as steam	42·0 „
Boiler efficiency from above $\frac{42}{52\cdot5}$	80·0 „
Efficiency of steam cycle	20·0 „
Power from steam = 20 per cent. of 42 per cent.	8·4 „
Total indicated thermal efficiency	55·9 „
Total brake thermal efficiency	44·4 „
Increase in indicated efficiency	17·7 „
Increase in brake efficiency	23·4 „

RED OXIDE INDUSTRY OF MALAGA.

One of the industries which has greatly developed in the Malaga district since the outbreak of the war, is that of manufacturing red oxide of iron for export. This product is used for making metal paint, especially for ships' bottoms; it also serves extensively as a colouring material for paper, rubber, tiles, etc. In recent years the red oxide of iron has been substituted to a great extent for red lead, which is much more expensive, besides being injurious to the health of the users. The hematite ores are found in the province of Jaen, about one hundred miles north-east of Malaga, and also at Salinas, in the province of Malaga.

A careful selection of the crude ore is required; and, although there are many different processes for its elaboration, the old-fashioned system of levigation appears to give the best results. The crude ore is thoroughly ground; the impurities in the ore are washed out as the ore runs through a series of tanks or basins, and only the very finest particles that remain in suspension in the water reach the last tank, where they are allowed to settle. The water is slowly drained off the washed oxide, which is then passed through filters and placed in the sun for a day or two to dry. In order to complete the drying artificial heat is resorted to. The resulting filter cake is then disintegrated, producing the impalpable powder of intense power for colouring—which is the levigated red oxide. The red oxide is usually packed in barrels containing about 300 kilogs (660 lb.) net.

Some of the oxide shipped from Malaga is dry ground (*i.e.* milled exactly as it comes from the mine without any washing) or passed through tube or ball mills. Although probably not as economical, the liquid process is said to give the best results.

According to a report by the United States Consul at Malaga, there are three factories in that town and one in Jaen, for the preparation of the oxides for export. The industry was established in 1900, but was relatively unimportant until the war caused exports from the islands of the Persian Gulf to cease. The exports from Malaga then increased considerably, until about 5,655 tons of levigated oxide of iron were exported in 1916, and 6,055 tons in 1917. A considerable amount of crude ore is also exported from Malaga, but by far the larger part of the export is shipped in the manufactured state, to save shipping space.

The analysis of the oxide, and more especially the ferric-oxide (Fe_2O_3) content, although insisted on by many buyers, would not appear to have any direct relation to the colouring power of the pigment. The Persian Gulf oxides, for instance, which have a more beautiful colour and stronger staining power than Spanish oxides, are much lower in ferric-oxide content. The value of an analysis consists probably in the proof that the oxide has not been adulterated in the course of levigation. Also, the higher the percentage of iron the greater is the value of the oxide as a preservative against rust. The higher grade Spanish oxides contain from 85 to 90 per cent. Fe_2O_3, but some of equally strong sustaining power contain about 80 per cent.

BUDDING THE WILD OLIVE IN BALUCHISTAN.

A work of much interest which is now being supervised by the Forest Department in Baluchistan is an attempt to bud the wild olive trees, which are plentiful in certain belts of country at a height of about 5,000 feet, with buds from cultivated European olives. In a report describing its work with the wild olives in that region, the Forest Administration in Baluchistan says that about two hundred European olives were imported from the South of France in 1910 and planted at Fazil Kach, and at Turwekan in a pass in the mountains between Hurani and Lorolai, in order to give a plentiful supply of buds for the wild trees in the neighbourhood. These imported trees have grown well, and they fruited in 1916. The fruit was large, and seemed to contain plenty of oil.

In 1911 a number of old, wild olive trees were cut down in order to produce by coppicing from their stumps young shoots fit for budding with the European olive. In 1914 these young, wild olive shoots were ready, and were budded in May. It turned out, however, that this was a little late in the year. Moreover, for the olive, the best bud appears to be the "resting bud," which should be put in in September. Only eleven out of the hundred buds put in in May, 1914, were successful. A few others have been tried in subsequent years, and there are now in all about fifty wild olive shoots budded with the European olive. The budded portions are growing vigorously, and should give fruit in a year or two. If it turns out that these budded wild olive shoots give, like

the European plants from which they were taken, good large fruit containing plenty of oil, it will then be worth while pushing the experiment forward on a great scale, and the eye of imagination can foresee that a flourishing olive-oil industry may arise in Baluchistan. There are numerous streams near the wild olive belts which could be used for turning mills to crush out the oil.

Experiments similar to the Baluchistan experiments are being carried on in Kashmir and the Punjab Salt Range.

JAPANESE BLACK MINT.

The black mint is grown, in Japan, in two widely different climates. About 92 per cent. is grown on the Hokkaido (Yezo), the large northern island, where the average winter temperature is about 22° F., with a minimum of 10° F. below zero, and the average summer temperature is about 60° F., with a maximum of about 90° F. The average yearly rainfall is about 38 inches. The remaining 8 per cent. of the mint is grown in the prefectures of Okayama and Hiroshima, on the main island, where the average winter temperature is about 38° F., with a minimum of about 20° F., and the average summer temperature is about 75° F., with a maximum of about 98° F. The average yearly rainfall in this district is 42½ inches.

According to a report by the United States Vice-Consul at Kobe, the mint plant requires a light, well-drained soil. The roots are planted (in Hiroshima and Okayama) at the end of November and the beginning of December. The plant attains its full growth during the summer months, and is cut in the latter part of July, during August, and in the early part of September, three cuttings being made during the season. The third cutting yields the greatest percentage of oil and menthol crystals. The leaves are steamed and pressed in barrels by the planters, who then ship them to the menthol factories, of which there are seventy-four in various parts of Japan. There the oil is extracted from the leaves by a process of freezing and pressing.

CANADIAN TRADE MISSION.

The Canadian Mission recently established in London was constituted by an Order of the Dominion Privy Council in November, 1918, and Mr. Lloyd Harris, a Canadian business man, accepted the position of Chairman at the request of the Prime Minister, Sir Robert Borden. The serious tonnage position arising out of the war, coupled with the numerous restrictions on import and export trade, tended to sever numerous old connections which had existed for generations between the Mother Country and the Dominion. It is one of the duties of the Mission to study the question at first hand, and to devise the means of re-establishing the traditional trade. A great work of reconstruction and reorganisation must be undertaken in Europe during the next few years. Raw materials, etc., will be necessary for this work, and it is pointed out that many articles required can be obtained from Canada. The Mission hopes, by negotiation with the Governments of the countries concerned, to make arrangements for the supply of such goods. It is further considering how, by a system of credits, to assist the Governments in purchasing the materials. The Mission is convinced that the resettlement of Europe is largely dependent on sufficient supplies of food being available and distribution being properly organised. Canada has large surpluses of foodstuffs, which she is willing to place at the disposal of Europe, and as she has always specialised in the manufacture of agricultural machinery and implements, she is in a position to come to the assistance of the nations of Europe in their endeavours to produce supplies within their own borders. The Mission will be glad to advise anyone desiring information about Canadian trade. The offices of the Mission are at 1, Regent Street, S.W. (1)

CORRESPONDENCE.

RAILWAY TRANSPORT IN THE UNITED KINGDOM.

I have read with interest the paper of Mr. Kelway-Bamber on railway transport, but it seems to me the heading "Mineral Wagon Earnings" is rather misleading.

The figures given show the average freight charged for the minerals carried rather than the earnings of the truck itself.

It may be that the average number of journeys of 10-ton trucks was thirty-five in a year, but this includes a preponderating number of trucks running short journeys from a colliery to the port (as in Wales and on the Humber), a class of traffic for which large wagons might well be substituted. On the other hand, many of these trucks are very old (forty or fifty years), and having gradually been practically entirely renewed, represent very little financial outlay.

The average loading of a 10-ton truck would probably be nearer 9½ tons than 10 tons.

As owner of a large number of trucks I may say the running to London over a year varied scarcely perceptibly for many years, being twenty-seven journeys a year.

The working arrangements made by the various railway companies in 1909 had the effect of dropping this to twenty-four journeys a year, and the arrangements of the railway executive during the war dropped this still further to 20·8 journeys a year. This drop arose, not from longer time taken with the full journeys nor from delays in unloading trucks, but from the inferior arrangements made for handling the empties.

To enable larger sized trucks to be run in London traffic would necessitate the construction of new depots with shoots, or the reconstruction of the

existing ones which are few in number, most of the depots being open sidings where the trucks would not have their contents expeditiously removed.

This would mean a very large expense. I believe even in pre-war times the construction of Somers Town involved a million pounds, and that was only a siding depot without shoots.

The existing turn-tables would be too small to enable the trucks to be put in position. If the trucks were too high in the side they could not be got under the wooden curtain.

HYLTON B. DALE.

335 & 337, Gray's Inn Road, W.C. 1,
May 26th, 1919.

Mr. Hylton Dale can speak with authority on the *duty* obtained from privately owned wagons working between the collieries and London, and the information given in his letter of May 26th is, for that reason, both interesting and valuable.

The reduction in the average number of wagon journeys from twenty-seven to less than twenty-one per annum is no doubt serious, but with the anticipated expansion in post-war business the figure, if low-capacity wagons continue to be standard for British railways, is more likely to fall than to rise.

The diagrams illustrating the paper gave what is thought to be a reasonable forecast of British railway working conditions during the coming thirty years, and showed the congestion certain to result from the continuance of practices no longer efficient or economical.

"Receipts per Mineral Wagons" would probably have been a better title than "Mineral Wagon Earnings" for the portion of the paper to which Mr. Dale refers, but it will be noted that the average receipts per mineral wagon as well as the freight rates were given.

H. KELWAY-BAMBER.

38, Victoria Street, S.W. 1,
May 30th, 1919.

GENERAL NOTES.

USE OF AEROPLANES IN FOREST PATROL WORK.—Of the total area of the United States approximately 24 per cent. is forested. Statistics secured during the past three years (1915–1917 inclusive) indicate that the average annual damage caused by forest fires amounts to approximately ten million dollars, and that there are upward of 28,000 forest fires annually in the United States. The chief object of forest patrol work is protection against fire. For this purpose the present method of detecting fires is by means of a system of well-selected look-out peaks. Mr. Henry S. Glaves, Chief of the U.S.A. Forest Service, is of opinion—although no experiments have as yet actually been carried out—that the method of detection of fires could be greatly improved by the use of aeroplanes. Several disadvantages of the present method are given, and the advantages of aircraft for the purpose are brought forward. As a means of prompt detection of fires in rolling or flat country it is doubtful if aircraft patrol could be excelled, and it is probable that by adopting aircraft patrol the numbers of men required could be reduced. Besides their use for fire detection, according to *Aviation*, aircraft would be very useful for scouting on large fires. It is the duty of a fire scout to determine each day how the fire is progressing in order that it may be fought to the best advantage, and in country where getting about from one place to another is difficult the use of aircraft would be especially advantageous. It is suggested that aeroplanes might be employed for the speedy transportation of fire fighters from point to point, and, further, that aeroplanes of the bombing type might even be of use in fighting fires by the dropping of fire-extinguishing bombs.

JAPANESE TRADE WITH INDIA.—Three decades ago the then Director-General of Statistics wrote: "Imports from Japan are quite trifling, averaging less than three lakhs annually in the last five years, and there are no indications of an increase unless the imports of copper should be resumed." The present Director-General, Mr. G. Findlay Shirras, in his report for the year 1917–18, writes: "When the long list of imports at the present time is examined, the progress in our trade with Japan cannot be termed other than extraordinary. In 1917–18 the total trade with Japan exceeded that with other countries except the United Kingdom, and was valued at Rs. 52 crores. This was an increase of 400 per cent. in imports and 103 per cent. in exports over the pre-war average." One interesting fact mentioned by Mr. Shirras is that in the year under notice Japan supplanted the United Kingdom as the largest supplier of beer to our Indian Empire!

KAURI-GUM OIL IN NEW ZEALAND.—The process of extracting crude oil, together with the by-products, acetic acid, ammonia, pitch, and gum spirit, from kauri peat-gum swamps, is progressing in New Zealand, and according to reports there seems to be an almost unlimited source of supply, since it is stated that one company has the rights covering 40,000 acres of these old swamp lands, and this is only a small portion of the total field. It is stated that the yield of crude oil ranges from 76 gallons per ton from the gum dirt to 168 gallons per ton from gummy timber. As yet, writes the United States Consul General at Auckland, no large quantities of the crude oil have been refined, and its actual commercial value has not been definitely established, but it is estimated that the business may become a profitable industry.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—June 6, 1919.

No. 3473. JUNE 13, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,473. VOL. LXVII.

FRIDAY, JUNE 13, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Sixty-fifth Annual General Meeting, for the purpose of receiving the Council's report and the Financial Statement for 1918, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 25th, at 4 p.m.

(By order of the Council),

GEORGE KENNETH MENZIES,
Secretary.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO SIR OLIVER LODGE.

The Council of the Royal Society of Arts attended at Clarence House on Friday, the 6th inst., when His Royal Highness the Duke of Connaught and Strathearn, K.G., President of the Society, presented its Albert Medal to Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S., "in recognition of his work as the pioneer of wireless telegraphy."

The members of the Council present were: Mr. Alan A. Campbell Swinton, F.R.S. (Chairman), Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., Lord Blyth, Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., Mr. Edward Dent, Mr. Peter MacIntyre Evans, Sir Robert Abbott Hadfield, Bt., D.Sc., D.Met., F.R.S., Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc., Lord Leverhulme, Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., Major Francis Grant Ogilvie, C.B., LL.D., Mr. John Slater, F.R.I.B.A., Dr. John Augustus Voelcker, and Sir Henry Trueman Wood, with Mr. G. K. Menzies, Secretary.

PROCEEDINGS OF THE SOCIETY.

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, May 28th; Sir RICHARD TETLEY GLAZEBROOK, C.B., F.R.S., Director of the National Physical Laboratory, in the chair.

The paper read was—

GLASS-MAKING BEFORE AND DURING THE WAR.

By HARRY J. POWELL.

It is just forty-four years since in this room I was called upon to make an authoritative pronouncement on a vital question connected with the manufacture of glass.

I was then a very young manufacturer of about six weeks' standing, and was naturally diffident. The question was whether M. de la Bastie's process of "toughening" glass could supersede the ordinary process of annealing. M. de la Bastie had superintended experiments in glass-toughening at the Whitefriars works, and on the evening to which I have referred his agent had read a paper before the Society explaining the great future of the so-called toughening process.

I had produced from my pockets a few specimen toughened tumblers, which were passed round the audience and escaped breakage, though repeatedly dropped. Toughened tumblers had a strange influence on the mentality of most of these who handled them The first phase was to push a tumbler very gingerly off the side of a table, if possible on to a soft carpet; the second, to stand on a chair and drop it from a considerable height; the third to roll it down a flight of stairs; and the last, to hurl it down on the stone doorstep, when it exploded into a thousand atoms.

A microscopic examination of the fragments

had proved to me that the glass was not toughened, but case-hardened, that the state of strain was immense, that the hardened glass was unreliable, and that the process could only be applied to the simplest forms of glass ware.

Fortunately, my diagnosis proved fairly correct.

It is perhaps not inappropriate that, after forty-four years' experience, my last paper connected with the manufacture of glass should be read before the Royal Society of Arts. Objection may be raised to another paper on glass manufacture following so closely Sir Herbert Jackson's valuable lecture on "Glass and Some of its Problems." My excuse is that the Society of Arts is interested in all matters connected with London, and that it is not sufficiently realised that glass-making is one of the oldest of London's industries, and at one time was of considerable importance. There is a continuous record for over 300 years of glass-making in London. John Houghton, writing in 1696, mentions twenty-four glass-houses in the London district. Mr. Francis Buckley, who has devoted immense labour to investigating the history of the London glass-houses, says that "until the latter end of the eighteenth century, London was the premier glass-making city in England." Important London glass-works are mentioned by Stowe, by Pepys, and by Evelyn. "Jacob Verzellini," whose Memorial Brass is still extant at the little church of Down in Kent (and of whose work I hope to show you two photographs), worked in glass-works in Crutched Friars and in Broad Street from 1575 to 1606. There were glass-works in Blackfriars near the Apothecaries' Hall in 1607. Later in the same century George Ravenscroft's glass-house in the Savoy was started. The Falcon Glass-works in Southwark, better known in later days as "Apsley Pellatt's Glass-works," were founded in 1693 and survived until 1877. Mr. Buckley, writing about the Whitefriars Glass-house, says: "It holds the unique position of being the only London glass-house of the eighteenth century that still survives on its original site." The earliest advertisement is in the *Tatler* of August, 1710.

I have strayed into history in order to prove that glass-making, as an ancient London industry, deserves rather more attention than it has received.

The title which I have chosen for my paper is "Glass-making before and during the War." I must preface my paper with an apology. Glass manufacture has very many sub-divisions, and until quite recently there has been no machinery to link the sub-divisions together. In the limited time at my disposal I have been unable to collect specimens of the war work of the sub-divisions, but many manufacturers have been good enough to send me summaries of the war work which they have carried out, and I hope that it may in time be possible to compile a complete statement.

The word *parlous* aptly describes the condition of the English glass trade before the war. Messrs. Chance kept alive with difficulty the manufacture of optical glass. A few automatic bottle-making machines had been introduced in some of the Yorkshire bottle works, and there were signs of vitality in the manufacture of hand-made and artistic table ware.

The unfortunate condition of the glass trade was attributed by men of science to ignorance and want of initiative on the part of the manufacturers; but by the manufacturers it was attributed to free trade, unfair trading conditions, and to the gulf dividing industrial from academic chemistry.

In 1872 Professor Barff delivered before this Society a course of Cantor Lectures entitled "Silicates, Silicides, Glass and Glass-making." These lectures, although necessarily sketchy, were scientifically helpful. From that time until 1915, when the Institute of Chemistry issued Sir Herbert Jackson's translations of analyses of a number of German glasses, no professor of chemistry in England had made any attempt to bridge the gulf or to throw any further light on the scientific principles underlying the manufacture of glass, a manufacture which is infinitely varied and is beset by innumerable scientific difficulties.

There was no institution from which scientific help could be obtained. This deficiency, I hope, may now be made good by the Society of Glass Technology of Sheffield University. There was no university, college or school, which offered facilities for training glass-works' managers. The Imperial College of Science and Technology, which received grants and endowments for post-graduate industrial research, was captured by pure science and utilised for cramming undergraduates for examinations. So far as I can ascertain, no research dealing with glass was attempted at the College until some time after war had been declared.

With two exceptions, all the glass-works were

small and were scantily equipped for research, and each manager was left to work out his own problems for himself, an obviously uneconomical arrangement.

Pure science, although greatly dependent on glass, consistently ignored the existence of the English glass industry, until some apparatus or some glass of special composition was unobtainable from Germany. Whenever these demands were made manufacturers gladly did their utmost to meet them. The following are a few examples of these demands.

Sir William Crookes, whose recent death we all so greatly deplore, required a number of glasses, which he had evolved in his laborious and successful research for a perfect anti-cataract spectacle glass, melted on a larger scale than he could manage in his laboratory; he also, for war signalling purposes, required sheets of glass containing oxide of didymium. Special glasses were produced for Lord Berkeley's researches in electrolysis, and glasses were also made for Professors Dobbie and Gray to illustrate the connection between electrical properties and the chemical composition of different kinds of glass. Going back to 1895, Professor Dewar wrote: "I am in extremity for the want of larger vacuum glasses for liquid air." On receiving some large vacuum cups from Whitefriars, he wrote: "I am delighted to tell you that they have stood every test." It is difficult to reconcile this letter with Mr. Duveen's statement, in his paper of March last on "Key Industries," when, referring to the thermos flask, he said: "In connection with any new scientific discovery where glass apparatus was required, we were compelled to send our ideas to Germany, where they were put into practical shapes." His statement as to tubes for testing poisoned water in wells, and as to accurate thermometers, is equally hard to understand.

Commencing from the year 1897 a series of tests of glasses for accurate thermometers has been carried out by the National Physical Laboratory. Writing in 1898, with reference to a glass tested by the National Physical Laboratory in 1897, the late Mr. J. J. Hicks, the well-known thermometer maker of Hatton Garden, said: "For the last eight or nine months I have been trying the 'Whitefrairs' 1897 glass and comparing it with 16.iii Jena glass, and I am pleased to find that there is no difference." The National Physical Laboratory gave the following report on thermometers sent in 1915: "In the zero tests, they were compared with a thermometer made of 'Jena' combustion tube (the most successful we have come across for highest temperature ranges), the experiments already carried out indicate that up to 100° C. or more the glass is unusually good." It was my hope to arrive at glasses superior in accuracy to the Jena 16.iii and 59.iii. Unfortunately, the issue by the Institute of Chemistry in March, 1916, of formulæ for the pre-war German glasses 16.iii and 59.iii, which were accepted by thermometer makers as official standards, has had the effect of postponing the development which I believed, and still believe, to be possible.

Before the issue of the formulæ for thermometer glasses I wrote to the Registrar of the Institute, asking whether glasses made to these formulæ had been tested by the National Physical Laboratory, and received the rather unsatisfactory reply that "it is *practically* certain that they will be suitable for the purpose." I then wrote to the Department of Scientific Research, and received an equally unsatisfying reply: "It is considered unlikely that glasses so closely resembling one another should give any discoverable difference in actual use." There was no suggestion that the formulæ represented glasses in any way superior to the pre-war types.

On April 23rd, 1917, after trying the Institute's formulæ for glass and enamel for 59.iii glass, I wrote to the Registrar saying that they did not seem to be quite satisfactory, and that I thought that there was still room for improvement in thermometer glasses. The Institute's formulæ represent pre-war glasses, the analysis of Jena 16.iii dating back to at least 1889.* It is quite certain that during the years of war the Jena works have not been entirely idle, and it is probable that they have ready for export glasses infinitely superior to the ancient 16.iii and 59.iii. If the glasses are better than English reproductions no tariff will keep, or ought to keep, them out of the country. The same objection applies to the formula for X-ray bulbs. It merely represents pre-war German bulbs, and I feel sure that improvements could be made. For instance, in 1911 I introduced lithium carbonate into the glass-batch with promising results. I doubt, too, whether even now the best possible glass or glasses for laboratory ware have been produced. No one can appreciate more fully than I do the exacting labour represented by Sir Herbert Jackson's experiments, and the patriotic intention and motive of the

* Guillaume's "Thermomètrie de Précision," published in Paris, 1889.

Institute of Chemistry in publishing the glass recipes; but, owing to the prestige of the investigators and of the Institute of Chemistry, and owing to certain injudicious notices of the press, these recipes were accepted by purchasers and dealers in glass as the very last word in scientific glass-making, with the result that scientific glass-making in England has, in some departments, been seriously hindered.

If, as no doubt was originally intended, the formulæ had been issued merely as possibly helpful suggestions, and if the Ministry of Optical Munitions had made arrangements for testing and reporting on glasses submitted by manufacturers in the same way as the National Physical Laboratory tests and reports on thermometers, it is probable that by degrees the best possible glass might have been evolved for every scientific requirement.

The effect of free trade on the glass industry was disastrous. Glass of all kinds, produced under conditions widely different from those existing here, came from abroad, and could be sold at prices actually below or very slightly in advance of the cost of production in England. Succeeding Governments were apathetic as to the fate of the industry. All was satisfactory, provided glass could be cheaply bought. Furnaces were damped down, works dropped out, and recruits for the trade were difficult to obtain. Manufacturers were gradually driven to relinquish one staple product after another. The following examples will illustrate the prices at which foreign glass was imported. Tumblers came into the country at 7*s*. 9*d*. per gross, wine-glasses at from 1*s*. 3*d*. to 3*s*. 6*d*. per dozen, pint water-bottles (including water tumblers) at 2*s*. 8*d*. per dozen. The price of laboratory glass ware was on a similar scale: Foreign test-tubes could be sold retail in London at from 1*s*. 6*d*. to 6*s*. per gross; hard-glass flasks, 50 c.c., at 2*s*. 6*d*. per dozen; 100 c.c. at 3*s*., 800 c.c. at 7*s*., and 1,000 c.c. at 8*s*. 6*d*. per dozen. Flasks, 50 c.c., at 2*s*. 6*d*. per dozen; 100 c.c., at 2s. 9*d*. per dozen; 500 c.c., at 6*s*. per dozen; and one-litre flasks at 8*s*. 6*d*. per dozen. French and German soda glass tube could be purchased at 3¾*d*. per lb.

English manufacturers were, before the war, accused of short-sightedness and want of initiative because they hesitated to adapt their works for the production of laboratory ware. Their prospect of financial success was microscopic. In justice to the English manufacturers it must be remembered that the German and Austrian furnaces and pots were and are adapted for melting a leadless glass, whereas the English furnaces and pots were adapted for melting a glass containing lead. Although the leadless (lime-soda, alumina glass) is better suited for making laboratory ware than a glass containing lead, it does not follow that it is for all purposes a better glass. Of the many hundreds of different glasses which are now made, the lead-potash glass, as a glass, is probably the most scientifically perfect glass in existence. Since the commencement of the war, in order to meet war requirements, English manufacturers have to a large extent given up making lead-glass and have made lime-soda, alumina glasses in its place. There has naturally been immense difficulty in building new works and in adapting old ones. The best was made of all sorts of makeshifts, and the work was done. These makeshift factories cannot now be expected to compete on equal terms with the pre-war factories of Germany and Austria, which have suffered in no way by war conditions, and which are perfectly organised and equipped for dealing with leadless glasses.

I have already said that the English manufacturers *before* the war were constantly being driven from one expedient to another to keep their works alive and to make a living. I will briefly sketch the experiences of a flint-glass manufacturer whose staple productions were originally flint-glass table ware and flint-glass tube. The earlier developments were coloured glasses for table ware and flower vases, and for shades for oil, gas and electric light. They were brought out in the following order: pale green, amber, blue opal, straw opal, sea green, sky blue, palest blue, chameleon, selenium orange, horn colour, and transparent black. There followed several processes of surface-decoration: iridisation, marvering on gold or platinum leaf, and marvering on mica scales.

Two soda-lime glasses were introduced for vases, one similar to Venetian glass, the other tinted blue with iron and based on an analysis of an ancient Roman jug. Glass engraving was used as a definite form of decoration, and not merely as a screen to cover defects in the glass.

The paper on "cut glass" read before this Society in 1906, refuting Ruskin's verdict that all glass cutting must be barbarous, led to a development of glass cutting on sane lines. This new form of cutting was designed to emphasise the brilliance of the material without destroying or obscuring the form of the vessel, due to the glass-blower's skill.

Concurrently with glasses for table ware,

many cloured glasses were produced for painted glass windows. Owing in no small degree to the richness of these colours, the competition was won for the seven three-light apsidal windows of the Cathedral of St. John the Divine, New York. The twenty-one lights, containing altogether about 2,000 feet of glass, form a band of intensely glowing colour.

When Sir William Richmond demanded English material and English workmen to carry out his designs for the mosaics for the Choir of St. Paul's Cathedral, two entirely new problems (so far as England was concerned) had to be solved. First, to find a perfectly durable cement which would set slowly and would not discolour; and, secondly, to create a very large number of brilliantly coloured enamels to fill the artist's palette. Eight thousand square feet of dome and roof and wall were covered with cement, in which over four million tesseræ were pressed, one by one.

In every glass factory there is a certain proportion of waste glass, which is unfit for remelting. This glass collected, and finely ground, forms the basis of an opaque glass, suitable for wall decoration. The decoration may take the form of tiles or mosaic. The colour, however, is on the surface and not through the substance of the glass, as in the enamels used for the mosaics in St. Paul's. The gold and silver used in mosaic is made by enclosing leaves of gold, silver or platinum between two layers of molten glass; if the upper layer is coloured, various effects of metallic colour can be obtained. A cameo effect is given by eating into the upper coloured surface with acid. In addition to making a variety of glasses, work was carried out in silver, brass, iron, stone and marble.

After war was declared the manufacture of vases and of fancy table ware was abandoned, and the cutting shops were denuded of men. A wine-glass chair drew tube for mine-horns; a decanter shop blew X-ray bulbs; a fancy chair made medical glass, and the output of clinical thermometer glass was doubled.

Carbonate of potash disappeared, the price having risen from £21 to £48 per ton, and was replaced by saltpetre. The price of other materials rose as follows: Saltpetre, £26 to £64 per ton; red lead, £23 10*s*. to £56 per ton; Fontainebleau sand (delivered in London), 21*s*. to 44*s*. per ton; white trioxide of arsenic, 32*s*. to 175*s*. per cwt.; precipitated oxide of manganese, 3*s*. 6*d*. to 12*s*. 6*d*. per lb. A number of soda-lime alumina glasses were introduced for mine-horns, for X-ray bulbs, and for ordinary temperature and high temperature thermometers. Resistance glass in four colours was made for ampoules. In smaller quantities, enamels were made for thermometers, sealing flux for X-ray bulbs, blue enamel for cat's-eye levels, and white opal for arc-lamp shades.

Sheet glass containing oxide of didymium was blown for Sir W. Crookes, and sheet glass containing oxide of uranium for the Admiralty. A neutral glass was made for goggles for acetylene welders, and a dense black glass for goggles for airmen. Glasses for anti-heat and anti-glare spectacles (containing oxide of cerium) were made for Mr. Melson Wingate, who has kindly sent an exhibit of finished glasses. Glasses and enamels for artificial eyes, and dense lead-glass for X-ray shields, were also melted.

Six hundred thousand mine-horns were made by the Hyposol Company, of Harrow Wealdstone, from the mine-horn tube, each mine-horn having first been tested by being taken from boiling water and plunged into ice water, and then by being twice dropped upon a sheet of lead from a height of 10 feet.

The following are summaries kindly sent to me by other glass-makers of their special war developments. The developments take the following forms: (1) New buildings; (2) new furnaces and equipment; (3) new departures in glass-making; and (4) increased output of staple productions. These developments were effected under great difficulties owing to shortage of men, and of materials. There was also a great shortage of seasoned glass pots (crucibles), and rapid (sometimes unfortunate) decisions had to be made on the merits of competing types of recuperative and regenerative furnaces.

Messrs. Bagley and Co., Limited, Glass Bottle Manufacturers, Knottingley, Yorkshire.—"We have concentrated our efforts in installing Owen's automatic bottle-making machines."

Messrs. Breffit and Co., Aire and Calder Glass Bottle Works, Castleford.—"We have devoted ourselves almost entirely to making jam and fruit bottles and food containers."

Messrs. Burtles, Tate and Co., Limited, Flint Glass Works, Manchester.—"We have made new classes of goods, previously made abroad, viz.: Chemical and lighting glass. We have increased our output by working eight-hour shifts."

The Edinburgh and Leith Flint Glass Company.—"We formerly made table ware, but during

the war changed over to electric-lighting bulbs of various types. We specialised in miniature lamps for miners' lamps; and lamps for trench and naval signalling. We have also specialised in wireless telegraph valve glass. We have made glass tube and rod and soft soda testing for lamp work. We made a large number of experimental coloured glasses for various purposes. New furnaces, economical in fuel consumption, were installed."

The Edison and Swan Glass Works, Ponder's End, Middlesex.—"By erecting new furnaces we have doubled our production of bulbs and tubing for incandescent electric lamps. Special glasses have been developed: (1) for bulbs for half-watt lamps; (2) for wireless telegraph valves; (3) special coloured glasses—red, green, and blue—for the Admiralty for signalling. These glasses had to be tested for the transmission of light of certain wave lengths; (4) a dark blue glass for ship lighting in cabins and holds, when the vessels were running with 'all lights out.' The light must be invisible at a distance of 100 yards on a clear night, and all red rays must be absorbed; and (5) opal tubing dense and transparent."

Messrs. Frank Tomey and Co., Thermometer Glass Makers, of the Borough Glass Works, Birmingham, write:—"Our war development has been in soda-glass-tube for laboratory ware, the output of which exceeds our output of all other kinds of glass. We increased our supply of ordinary thermometer glass, and also supplied dairy thermometer tube, insulated thermometer tube, 'Normal' and boro-silicate tube."

The Hon. Secretary of the Northern Association of Pressed Glass Manufacturers writes as follows:—"There is little to be said about war developments except that the introduction of labour-saving machinery will before long replace the antiquated glass-workers by female labour and practical engineers."

Messrs. Greener and Co., Wear Flint Glass Works, Sunderland.—"In order to meet the shortage of labour, due to the large number of men called up, labour-saving machines were obtained from America for making tumblers and other drinking vessels for the Army and Navy and for hospitals. These machines fully justified their heavy cost. Additional furnaces were installed. A large recuperative gas furnace was built by one man, with a lad to assist him, in eighteen months."

Messrs. Molineaux, Webb and Co., Ancoats, Manchester.—"We concentrated on lighting, chemical and medical goods, and gave up ordinary table glass."

Messrs. Pilkington Bros., Glass Works, St. Helens.—"There has been little opportunity during the war to increase our trade. Over four thousand of our men joined up, mostly as volunteers, and we were obliged to close a large part of our works. That part of the plant where we were able to keep going has been largely devoted to the supply of glass required by the War Office and Admiralty. For instance:—

"1. Many millions of glass circles for the eye-pieces of anti-gas masks.

"2. Large quantities of special photographic sheet glass for dry plates for the Air Service.

"3. Practically the whole of the glass for soldiers' hutments in all parts of the United Kingdom and abroad, and for aerodromes, and factories.

"4. Glass screens for Mechanical Transport Service.

"5. Glass for searchlight projectors.

"6. Glass tables used in production of picric acid.

"7. Non-actinic glass, to cut out the ultra-violet rays, for the roofs of aerodromes.

"8. Special blue glass for the stern lights of battle and merchant ships to render interior lights invisible."

Messrs. Stevens and Williams, manufacturers of table and decorative art glass, of Brierley Hill, near Stourbridge.—"While supplying very large quantities of table ware for the Army and Navy, we added the manufacture of chemical and medical glass ware in considerable variety, miners' lamp glasses, electric bulbs and lighting glass ware. These developments and the serious depletion of our staff necessitated the abandonment of the production of decorative glass. For producing the various kinds of chemical, laboratory and lighting glass ware, a glass was used of a special formula."

Messrs. Stuart and Sons, manufacturers of glass table ware, of the Red House Glass Works, Stourbridge, erected a new furnace for making electric light bulbs, and are now turning out about 40,000 bulbs per week.

Messrs. Thomas Webb and Sons, manufacturers of table ware and decorative glass, of the Dennis Glass Works, Stourbridge, specialised, at the request of the Ministry of Munitions, in making electric lamp bulbs, glass tubing and rod, and are now turning out 400,000 bulbs per month in addition to from six to eight tons of tubing and glass rod. They also manufacture

certain lines of chemical ware, such as funnels, test glasses, gas bottles, etc. Their output of table glass has been maintained. They are convinced that with some reasonable measure of protection this country could produce the bulk of the table glass required.

Messrs. Moncrieff, of the North British Glass Works, Perth, whose staple pre-war product was glass tube for gauge glasses, received an urgent wire on the morning following the declaration of war for glass parts for aeroplanes. These had to be made in the laboratory, but arrangements for lamp work on a larger scale were immediately set on foot.

The installation of new acid plants throughout the country necessitated the introduction of new methods of working up heavy tube at the lamp and at the furnace for the apparatus required. When the stocks of foreign combustion tube in this country were nearly exhausted, Messrs. Moncrieff produced a combustion glass, based on a formula supplied by the Institute of Chemistry, which is probably superior to the Jena combustion glass. By the end of 1914, at works taken for the purpose in Edinburgh, they were producing small quantities of laboratory ware, made of resistance glass. The majority of their glass-blowers having joined the Army, they were unable, owing to shortage of labour, to produce laboratory ware in any quantity until the spring of 1915. Early in 1916 the laboratory ware department was transferred to Perth, where a new twelve-pot furnace had been installed; since 1916 two new furnaces have been added. A demand for very large quantities of miners' safety-lamp glasses of approved quality has also been met.

Duroglass Works, Walthamstow.—Dr. Morris W. Travers, F.R.S., till lately scientific director of Duroglass Ltd., established by Messrs. Baird and Tatlock in conjunction with himself in 1915), writes as follows:—

"After preliminary investigations of foreign glasses (used in the manufacture of scientific glassware) which were carried out in the chemical department of the Imperial College at South Kensington, a small experimental oil-fired furnace, capable of melting glass in quantities of about one hundredweight at a time, was erected at Walthamstow in March, 1915, and experiments were carried out on the basis of the information which had been collected.

"Tube and beakers were made from these glasses, and as the result of these experiments it was decided to proceed with the manufacture of:—

"(1) A soda-potash-lime-alumina-glass for lamp-working, and

"(2) A zinc boro-silicate resistance glass for beakers, etc., somewhat similar to Jena glass, but free from the defect of yielding zinc to acid solutions.

"By June, 1915, the manufacture of tube and hollow ware was being carried out on a commercial scale, and during the following years the works were greatly extended, additional furnaces being built, with the necessary finishing shops for scientific hollow ware.

"And the manufacture of graduated and lamp-blown apparatus was developed on a considerable scale. Special attention has been paid to the development of mechanical methods in all departments.

"The annealing of glass ware was very carefully studied, and the special gas-fired lehrs which have been installed, and which can be regulated with great exactitude, have proved a great success. Glass ware is tested by means of a 'Hilger' strain viewer before being sent out."

Wood Bros. Glass Company, Borough Flint Glass Works, Barnsley.—"Prior to the war we were engaged almost solely in making flint-glass bottles for pharmacists.

"After the declaration of war, and before the end of 1914, we were turning out fair quantities of electric-light bulbs. In 1915 we built a large extension to our works, and, with the assistance of Sir Herbert Jackson, successfully tackled the manufacture of all kinds of laboratory and scientific glass ware. We also made flash-lamp lenses and X-ray bulbs. We built an additional furnace at the Derby Crown Glass Works, which had been started in 1913, mainly for the production of glass jars for potted meats, toilet cream, and for malt. Early in 1916 the Derby Crown Glass Company, at the request of the Government, decided to erect large new works with laboratories entirely for the manufacture of optical glass. The first melt on a commercial scale was made on June 3rd, 1916. In spite of the magnitude of the research work involved, many tons of optical glass of the highest quality were supplied during the war. The present list includes over forty distinct types, including reproductions of some of the most famous German glasses.

"The company is greatly indebted to the Optical and Glassware Department of the Ministry of Munitions for assistance and encouragement."

Mr. Christopher Wilson, Director of the Osram-Robertson Lamp Works, of Hammersmith, and of the Lemington Glass Works, Lemington-on-Tyne, said that before the war the Lemington Glass Works only turned out about 8 per cent. of the electric-light bulbs and glass tubing used

for Osram-Robertson lamps. After the outbreak of war two large regenerative gas-furnaces were erected, which melted and plained flint glass within twelve hours. The output of glass was enormously increased, and the shortage of labour was met by taking on and training boys of fourteen. Before the Armistice 400,000 bulbs were being produced each week in addition to tube. Mr. Wilson informed the author that he is now installing two American "Westlake" automatic bulb-blowing machines, which will greatly add to the speed and economy of production.

Messrs. Chance Brothers and Co., Glass Works, Smethwick, Birmingham.—"Before the war, in spite of the competition of the Jena firm which received substantial support from the German Government, we continued to manufacture optical glass at a pecuniary loss. When war was declared, and the supply of German glass was cut off, our experience as makers of optical glasses proved of inestimable value, and our output of optical glass has been increased twenty-fold. In addition to supplying home requirements we have to a considerable extent met the demands of the Allies. Our pre-war varieties of optical glass sufficed for the large majority of war requirements.

"Since the commencement of the war, the number of varieties has been greatly increased, and now covers practically the whole range of those made previous to the war by German and French manufacturers; and in some cases we are now in a position to offer varieties which have not hitherto been listed. As an instance of this, we may mention fluor crown and dense barium crown of exceptionally low dispersion.

"An exacting programme of work was undertaken in connection with the demands of the Air Board for special types of glasses required for the manufacture of the finest anastigmatic objectives for aerial photography. This was successfully carried out, and the photographic lenses made with the glass produced by the firm have been acknowledged to be far superior to those used by the Germans for similar work

"Special coloured glasses required for sextants and other optical instruments have also been investigated, and several types manufactured on a large scale, enabling us to offer four types of neutral tinted glass, besides plate glass for transmitting ultra-violet, a specially transparent blue filter and a uranium glass of great intensity of fluorescence.

"The special new glasses which we were called upon to make were investigated in our research laboratory, and the formulæ were worked out without any outside assistance. The statement in the press that the formulæ and methods we had used for the manufacture of glasses required for gun-sighting telescopes, field-glasses and range-finders, had been supplied by outside sources, was entirely without foundation and arose from confusion, on the part of the press, between Jena laboratory ware glass and Jena optical glass.

"In another department of our works we took up the manufacture of high-pressure lamp globes and heat-resisting glass, and have now captured the trade which, before the war, was entirely in the hands of enemy countries. We also produced, in some quantity, two types of Sir William Crookes' spectacle glasses. We made more than one and a half million goggles for the armies in Mesopotamia and in North Russia, and we cut ten million circles of sheet glass for gas-masks."

The future prosperity of England is said to depend upon increase in industrial production. Increased output means scrapping less perfect for more perfect machinery and, wherever possible, substituting mechanical for manual work. Glass-blowing is essentially a handicraft; it is slow, production is small, and the necessary manual efficiency is acquired, with difficulty, after prolonged training. The demand for increased output of glass may be the death sentence on the handicraft. I was present a short time ago at a meeting of representative glass manufacturers at which the hope was expressed (with only one dissentient) that within a few years all forms of glass ware might be mechanically produced. Automatic machinery has already been applied to the production of bottles, tumblers, chimneys, electric-light bulbs, sheet glass and tube. Moreover, nearly every form of table ware can be produced by moulding, by air pressure or by pressure of mechanically driven plungers. Already properly made tumblers and properly made wine-glasses are becoming rare. By properly made. I am antiquated enough to mean hand-made. The hand-made glasses are rather thicker and considerably less brittle than the moulded glasses. They taper slightly in substance, and the edges are softly rounded and not abrupt and sharp. The blown wine-glass foot also tapers, and is slightly hollow, whereas the mechanically squeezed foot is as flat as a biscuit. The passing of the handicraft cannot be regarded without some feelings

of regret. The hand-made vase may be mathematically inaccurate, but it is eloquent of the sensitive skill of a man's hand, and possesses individuality. The mechanically made vessel may possess mathematical accuracy, but has no living interest, and can be indefinitely reproduced. That much of the mechanically produced table ware is at present ugly and grotesque is the fault of the designer. The mechanically made vessel which pretends to be hand-made or hand-cut must always be a pretentious and unsatisfactory fraud. It is quite possible, however, to design table ware for mechanical production which shall be gracious in form and which shall possess sufficient decoration to accentuate the beauty of the material. Designs, whether for hand-made or mechanically produced table ware, must be evolved from intimate acquaintance with the nature of molten glass and the technique of manufacture, rather than from the superior inner consciousness of the Art School. A proposal has been made that industrial designers shall be trained in some central institution and sent out to reform and enlighten the benighted manufacturers. I venture to think that every would-be designer for glass, after acquiring the power to draw accurately, before being allowed to design, should first study in a glass house to learn the nature of glass and how glass vessels are made, and then pass through a course of study in museums to learn how the best specimens of glass craftsmanship were made in the past.

It has been my misfortune on several occasions to examine the designs for glass sent up for the National Art Competition. These designs almost invariably showed the competitors' ignorance of technique and of the nature of glass. Paying very little attention to form, the designer crammed in as much incongruous and unsuitable decoration as the available space could contain. The result was necessarily irritating. Study of pre-war decorative glass from Venice, Austria, and the United States convinced me that the designers had failed through an unwholesome craze for excessive ornament and crude colour.

Right design for glass must always be simple. Form must flow from the nature of the molten material, and the decoration, if any, must merely eulogise the inherent beauty which the material possesses. I must apologise for this divergence on design (a subject on which I feel very strongly), because it belongs rather to the future, than to the past or the war period; and the future of the English glass industry is, to say the least, uncertain.

In my paper I have endeavoured to illustrate the condition of glass manufacture in England before the war and the many developments which have been effected during the war. Before the war a manufacturer's only chance of survival was to specialise in some branch or branches of the manufacture which were not acutely affected by foreign competition. In spite of almost overwhelming difficulties, with no encouragement from the representatives of science, and with every discouragement that succeeding Governments could impose, although the number of glass houses and glass-makers had been greatly reduced, a small band of manufacturers kept the craft alive, and in at least one department brought the making and working of glass to such perfection that they became the unwilling pattern-makers for Germany and the United States. The experience of these manufacturers made it possible after the outbreak of war to meet nearly all the innumerable demands which war created. The question now to be decided is whether the great development in glass manufacture brought about by the war is to be maintained or to be scrapped. Severe pressure is already being applied to the Government to obtain permission for the unrestricted importation of glass ware from abroad. If unrestricted imports from Europe, from the United States, and from Japan, are allowed, there is very little hope for the survival of the British glass industry.

I have already said that through unfair foreign competition English manufacturers before the war were constantly being driven from simple to more complex and specialised productions. This development took place in all glass works, but its form differed. The lantern-slides will show the course of development in one manufactory only. The specimens on the table illustrate the nature of the work in the same factory before and during the war.

DISCUSSION.

The Chairman (Sir Richard Tetley Glazebrook, F.R.S.), in opening the discussion, said a good deal had been heard as to the past history of glass manufacture in this country, which past history, he was afraid, had been in many respects, at any rate before the war, a very sad one. The author stated that "the unfortunate condition of the glass trade was attributed by men of science to ignorance and stupidity." He hoped the author did not

include in those men of science those with whom he had recently come in contact, and who had been doing all they could to help to improve the glass trade during the war. Everyone interested in glass work knew that the problems which glass manufacturers had to solve (many of which they had solved with great success) were of extreme difficulty and complexity, and speaking for himself, and for those of the staff of his laboratory with whom he had been connected, he would like to say that it had been a great pleasure to them to help as far as they could in some small way the work which had been going on at the Whitefriars glass works before the war and the work which had been going on throughout the country since the war. In particular, perhaps he might refer to work dealing with the refractory materials which were necessary for making the pots and furnaces for glass manufacture. He thought, too, that the author should be thanked very sincerely for the trouble he had taken in collecting together the list of the work and experiences of other manufacturers during the period of the war. The list was a very striking one, and could not fail to be of importance and of use. The real question which the author raised was what was to be done to maintain the glass trade of the country in the condition which it had reached under the stress of war? It was a problem which concerned not only the glass trade but very many other branches of British manufacture, and it did appear to be clear that some very strong steps would have to be taken by the Government if we were to retain the supremacy which we had won during the war in glass manufacture as well as in other branches of scientific manufacturing work.

Dr. M. W. Travers, F.R.S., remarked that his own connection with the glass trade had begun with the war, owing to an almost accidental circumstance, but he could only say that he had found the study of glass most fascinating. Apart from the scientific aspect of the problems involved, there was an almost human character about the behaviour of glass in the glass house, which could only be studied on the spot. He could fully appreciate the author's statement that it would be useless to attempt to design a piece of laboratory apparatus, much less a piece of ornamental glass ware, unless one knew how glass would behave when taken from the pot on to the iron and then put through various processes. Although he realised very clearly that in the future machinery must play a larger part in the glass house, he hoped, and he thought that every Englishman must hope, that there must always remain a place for that branch of the glass trade represented by the author's firm, in which craftsmanship was the most important factor. British manufacturers and British craftsmen had long held, and would, he believed, maintain the highest position in this branch of the glass industry. During the war British glass manufacturers had learned that much more was to be gained through co-operation than through jealously guarding trade secrets, and never allowing anyone to enter the glass factory. A saying was attributed to Mr. Owens, the distinguished American glass engineer, that "if a manufacturer refused to allow him to visit his factory, it meant that he was ashamed of it," which had probably much truth in it. The growth of the Society of Glass Technology, with its five hundred members, was one of the best signs of the growth of the new spirit, for at the monthly meetings technical and scientific matters connected with the industry, which before the war would have been regarded as trade secrets, were freely and openly discussed.

Captain Noel Heaton sympathised with the remarks of the author in regard to a glass-maker being a craftsman rather than a hand. One deprecated, with the author, the tendency to eliminate the craftsman by relegating everything to machine production. He did not think that all that delightful table glass which was such a feature of the Whitefriars glass works, and which had been such a great feature particularly of the English glass industry, should be allowed to be supplanted entirely by machine-made work.

Professor Herbert Brereton Baker, F.R.S., bore his testimony to one of the latest products of the glass-making industry of this country, namely, mine-horn glass. He had to confess that, during the war, when a great part of his work had consisted in making very delicate glass apparatus, he had wished for the old times back again when one had German glass; but now one did not want anything more perfect than that produced in this country. He had been trying to cut a piece of British-made tubing that morning in the traditional manner, by making a fault mark and putting on a drop of hot glass, but the tubing did not crack. The resistance between the hot and the cold had been so extraordinary that he had had to use a diamond. No German glass would stand that.

Mr. W. F. Higgins corroborated the author's statement with regard to thermometers. He desired to call attention to one thermometer which the author had not mentioned, and that was a thermometer made for standing very high temperatures. It was also provided with a white enamel back, and no German thermometer had ever been made, to his knowledge, with a white enamel back which would stand a temperature of 500° C. as the particular instrument to which he was referring would. To his mind it was a very great advance on many of the German thermometers. His laboratory had not had a very large number of thermometers to test, but of the glasses they had received, by far the largest number were quite equal to the Jena glasses, both the 16.iii. and the 59.iii., and in one or two cases the zero depressions had been distinctly better. They had not had much time to investigate the secular change, but as far as one could tell that was equally satisfactory.

MR. E. A. COAD-PRYOR said the author has given a very clear outline of the work which had been done during the war, and all must agree that from an artistic point of view there was really nothing more to be said. But, regarding the glass from the point of view of industry, it must be clear that the economic factor came in, and must more or less control it. He would like to ask the author one question. For some reason or other the Germans were able to produce glass ware considerably cheaper than this country, and mechanical devices must, of course, lower the cost of production. Did the Germans before the war use mechanical devices for moulds, and so on, to blow glass, and was that a factor in the cheapness with which they were able to produce glass? If that was so, the introduction of mechanical means would help very largely to put us on a level with the Germans from that standpoint.

LIEUT.-COLONEL ALAN CUNNINGHAM asked if the toughened glass referred to in the paper was of the same nature as the toy which used to be known as the Prince Rupert's drop?

MR. LEON GASTER said he understood that the percentage of breakages of glass bulbs made in this country was much higher than that of the glass bulbs which used to be imported into Britain. Was that due to the difference in manufacture or to the unskilled labour employed, or to what was it due? The shortage of lamps during the war had been largely due to that excessive amount of breakage.

MR. H. J. POWELL, in reply, said there was no doubt that all the German glass works had employed mechanical means to a very much greater extent than this country had in the past, but now by degrees mechanical means were being much more largely used here. Colonel Cunningham was quite right in saying that toughened glass was analogous to the Prince Rupert's drop. With regard to the breakage of bulbs, he was afraid he could not answer Mr. Gaster's question. It was almost a new industry in England, and he had no doubt that as it went on great improvements would be made. He should think that great improvements might be made in the actual glass that was used. He was quite hopeful that that question of breakages would be got over before very long.

On the motion of the CHAIRMAN a vote of thanks was accorded to the author for his interesting paper.

THE MATCH INDUSTRY IN BRAZIL.

The total yearly production of the Brazilian match factories is from 380,000 to 420,000 tins of 8½ gross (1,200) boxes, each box containing from 50 to 60 matches. Two types of matches are manufactured—wooden safety matches, modelled after the Scandinavian type, and wax safety matches. The comparative production of these two kinds, writes the United States Vice-Consul at Rio de Janiero, cannot be ascertained exactly, but it is estimated that of the above total of about 400,000 tins, only between 30,000 and 40,000 tins, or about 10 per cent., are of the wax variety.

Practically no matches are imported from abroad owing to the high customs duties protecting the domestic industry.

The chief raw materials used by the Brazilian match factories are: (1) wood from the Brazilian pine, the so-called Parana pine, grown in the southern states of the republic; and (2) paper made from imported pulp, with which, on account of the high duty on this class of article, the imported paper cannot compete. In addition to these materials, the following are imported annually: Chlorate of potash, about 400 tons; paraffin, about 400 tons; glue, about 40 tons (a special match glue); gum arabic, about 35 tons; sulphur powder, about 40 tons; bichromate of potash, about 20 tons; and amorphous phosphorus, about 15 tons.

Formerly the matches were packed in tin plate or terne plate without further outside packing, but since the prices of all kinds of plate have increased considerably, and exports from producing countries have been restricted, wooden cases have been substituted and are now used almost exclusively. From 600 to 800 tons of tin and terne plate were formerly consumed every year in the Brazilian match industry.

OBITUARY.

SIR BOVERTON REDWOOD, BT., D.SC., F.R.S.E.—Sir Boverton Redwood, who died, after a very short illness, on June 4th at his residence in Avenue Road, Regent's Park, was long and closely associated with the Society. He was elected a member in 1885. In the following year he gave a course of Cantor Lectures on "Petroleum and its Products," and in 1904 he was elected to the Council, on which he continued to serve, with the necessary intervals required by the by-laws, until the time of his death. He also took the chair at various meetings of the Society, and he frequently spoke in the discussions.

Born in London in 1846, he was educated at University College School, and then entered the laboratory of his father, Theophilus Redwood, who for over forty years was Professor of Chemistry to the Pharmaceutical Society. In 1869 he became secretary of the Petroleum Association, and he decided to specialise in the study of oil. He soon came to be recognised as an authority on this subject. In 1872 he gave evidence on the testing of petroleum before a Select Committee of the House of Lords; and he collaborated with Sir Frederick Abel in investigations connected with the close test for the flash-point of petroleum, which was legalised in 1879. In 1886 he began to study the viscosity of oil, and as a result of his

work he produced the standard instrument known as the Redwood viscometer.

In 1883, and again in 1886, he accompanied Sir Vivian Majendie, then Chief Inspector of Explosives, on visits of inspection to the principal centres of petroleum distribution in this country, the more important European centres, the United States and Canada, and in 1892 he went to Egypt in connection with the carriage of oil in bulk through the Suez Canal. He became technical adviser to the Admiralty, the Home Office, the Corporation of London, the Port of London Authority, and other Government departments and public bodies, and in 1912 he was appointed a member of Lord Fisher's Royal Commission on Oil Fuel for the Navy.

During the war Sir Boverton did much valuable work on various Government committees. He assisted in forming the Petroleum Supplies Branch at the Ministry of Munitions in 1917, and he became Director of Petroleum Research, and subsequently Director of Technical Investigations in the Petroleum Executive, in which capacity he had to deal with all technical questions, including the co-ordination of the work of petroleum production and research. He was also chairman of the Gas Traction Committee.

Among his numerous activities Sir Boverton took a prominent part at the International Inventions and Health Exhibitions, and the Brussels, Paris, St. Louis, Franco-British, Rome and Turin Exhibitions. He was a member of the Delegacy of the City and Guilds (Engineering) College, Imperial College of Science and Technology; and he was one of the founders of the Institution of Petroleum Technologists, of which he acted as first President from 1914–16. He wrote a number of works on petroleum, including his important Treatise, first published in 1896, and of which the third edition appeared in 1913.

Sir Boverton was created a knight in 1905 and a baronet in 1911.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 16...Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Annual Address by Lieut.-Colonel G. MacInlay, "The Literary Marvels of St. Luke."

East India Association, Caxton Hall, Westminster, S.W., 4 15 p.m. Sir J. Douie, "Races of the Punjab and North-West Frontier Province: Manners and Religions."

Geographical Society, Burlington-gardens, W., 8.30 p.m.

TUESDAY, JUNE 17...Statistical Society, 9 Adelphi-terrace, W.C., 5.15 p.m. Mrs. W. J. Barton, "The Course of Women's Wages."

African Society, Connaught Rooms, Great Queen-street, W C., 7.30 p.m. Sir H. Clifford, "Recent Developments on the Gold Coast."

Anthropological Institute, 50, Great Russell-street, W.C., 8.15 p.m. Mr. J. R. Moir Flint, "Implements from the 'Middle' Glacial Gravel at Ipswich."

Asiatic Society, 22, Albemarle-street, W., 4 p.m. Miss F. E. Newton, "A Journey into Arabia by the Hedjaz Railway."

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. Messrs. E. Heron-Allen and A. Earland, "Exhibition of Lantern-slides illustrating the Cultivation of *Verneuilina polystropha* Reuss., in Hypertonic Sea-water and Gem-sand." 2. Mr. C. Morley, "Equatorial and other Species and Genera of African Ichneumonidæ." 3. Dr. C. W. Andrews, "A Description of New Species of Zeuglodons and Leathery Turtle from the Eocene of Southern Nigeria." 4. Mr. G. A. Boulenger, (a) "A List of the Snakes of West Africa from Mauritania to the French Congo" (b) "A List of the Snakes of North Africa."

Colonial Institute, Central Hall, Westminster, S.W., 8 p.m.

WEDNESDAY, JUNE 18...Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Colonel Sir C. Close, "Note on the Rainfall at Southampton and London during a Period of 57 Years (1862–1918) with Special Reference to the Monthly Means." 2. Lieutenant J. Logie, "Note on Tornadoes." 3. Captain D. Brunt, "A Periodogram Analysis of the Greenwich Temperature Records." 4. Lieutenant G. Green, "On the Propagation of Sound in the Atmosphere."

THURSDAY, JUNE 19...Mining Engineers, Institution of, at the Geological Society, Burlington House, W., 11 a.m. 1. Lieut.-Colonel D. Dale Logan, (a) "The Difficulties and Dangers of Mine-rescue Work on the Western Front; and Mining Operations carried out by Men wearing Rescue-apparatus"; (b) "Accidents due to Structural Defects of Apparatus or Injury to Apparatus; and the Future of the Proto Apparatus." 2. Messrs. M. Wynter Blyth and L. T. O'Shea, "The Examination of Coal in Relation to Coal-washing." 3. Professor F. W Hardwick, reply to discussion on his paper on "The Training of Students in Coal-mining, with Special Reference to the Scheme of the Engineering Training Organisation." 4. Mr. W. Maurice, "The Education of Colliery Managers for Administrative and Social Responsibilities." 5. Discussion on following papers already published:—(a) "A Method of Determining the Magnetic Meridian as a Basis for Mining Surveys"; (b) "Digest of the *First Report of the Mine Rescue-apparatus Research Committee*"; (c) "The Chance Acetylene Safety Lamp"; (d) "Recent Developments in the Coalfields south of Sydney."

Chemical Society, Burlington House, W., 8 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. T. A. Dymes, "Notes on the Life-history of the Yellow Flag, *Iris Pseudacorus* Linn., with Special Reference to the Seeds and Seedlings during their First Year." 2. Dr. G. H. Rodman, "Egg-case of a Spider from the South of France—*Cyrtarachne tuberculifera*" 3. Mr S. L. Moore, "A Contribution to the Flora of Australia." 4. Mr. A. W. Waters, 'Observations on Certain Species of Bryozoa, chiefly belonging to Selenariadæ, Conescharellinidæ, etc." 5. Dr. E. Penard, "Studies on some Flagellata." 6. Dr. W. M. Tattersall, "Report on the Stomatopoda and Macrurous Decapoda collected by Mr. Cyril Crossland in the Sudanese Red Sea"

China Society, School of Oriental Studies, Finsbury-circus, E C., 3.30 p.m. Address by His Excellency Liang Chi-Chao, "National Characteristics of the Chinese."

Numismatic Society, 22, Albemarle-street, W., 6 p.m. Address by the President, "Contributions to Cretan Numismatics.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W. 5.30 p.m. Mr. W. H. Goodchild, "The Genesis of Igneous Ore Deposits."

FRIDAY, JUNE 20...National Housing and Town Planning Council, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 10.30 a.m. to 1 p.m. 2.30 p.m. to 5 p.m. Conference.

SATURDAY, JUNE 21...National Housing and Town Planning Council, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 10.30 a.m. to 1 p.m. 2.30 p.m. to 5 p.m. Conference continued.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—June 13, 1919.

No. 3474. JUNE 20, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures, and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,474. VOL. LXVII.

FRIDAY, JUNE 20, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FINANCIAL STATEMENT FOR 1918.

The following statement is published in this week's *Journal* in accordance with Sec. 40 of the Society's By-laws:—

INCOME AND EXPENDITURE ACCOUNT,

January 1st to December 31st, 1918.

Dr.

		£ s. d.	£ s. d.
To *Journal*, including Printing, Publishing, and Advertisements		2,131 6 1	
,, Library and Bookbinding		73 18 2	
,, Medals:—	£ s. d.		
Albert	22 3 0		
Society's	13 18 0		
		36 1 0	
,, Sections:—			
Colonial	74 1 11		
Indian	114 10 3		
		188 12 2	
,, Cantor Lectures		198 7 0	
,, Donation to Board of Scientific Societies		10 10 0	
			2,638 14 5
,, Expenses of Examinations			4,086 1 7
,, House—			
Rent, Rates, and Taxes		861 12 1	
Insurance, Gas, Coal, Expenses and Charges incidental to Meetings		374 1 5	
Repairs		83 7 0	
			1,319 0 6
,, Office Expenses:—			
Salaries, Wages, and Pensions		2,775 8 9	
Stationery and Office Printing		553 5 6	
Advertising		58 0 0	
Postages, Parcels, and Messengers' Fares		171 15 1	
			3,558 9 4
,, Committees:—			
Industrial Art		42 12 7	
General Expenses		39 4 6	
			81 17 1
,, Interest on Bank Loan			95 0 0
,, Juvenile Lectures			20 0 0
,, Income Tax repaid to Trusts			40 1 10
,, Balance, being Excess of Income over Expenditure transferred to Capital Account			796 4 10
			£12,635 9 7

Cr.

	£ s. d.	£ s. d.
By Subscriptions	4,745 13 0	
,, Life Compositions	1,034 18 0	
		5,780 11 0
,, Interest and Dividends on Society's Investments	482 6 8	
,, Ground Rents	368 3 4	
,, Interest, Dividends, and Ground Rents from Trust Funds for General Purposes	503 0 11	
Do. from Building and Endowment Funds	22 7 5	
		1,375 18 4
,, Sales, etc.:—		
Journal	127 4 4	
Do. Advertisements	31 10 0	
Cantor Lectures	25 16 6	
History of the Society	0 15 0	
Reports of the Committee on Leather for Book-binding	1 6 11	
		186 12 9
,, Examination Fees and Advertisements in and Sale of Examination Papers		4,349 15 9
,, Charges for Expenses for the Use of Meeting Room		143 6 6
,, Return of Income Tax		799 5 3
		£12,635 9 7

TRUST INCOME AND EXPENDITURE ACCOUNTS.

Dr.		£ s. d.	Deficiencies on Trust Revenue December 31st, 1918. £ s. d.
Benjamin Shaw Trust—			
To Balance, January 1st, 1918	£ s. d.	10 8 4	
Less Interest on Investments	4 13 6		
Income Tax returned ...	1 4 0		
		5 17 6	
			4 10 10
,, Balance forward			478 13 8
			£483 4 6

Cr.		£ s. d.	Trust Accumulations December 31st, 1918. £ s. d.
John Stock Trust—			
By Balance, January 1st, 1918		13 17 7	
,, Interest on Investments		3 10 2	
,, Income Tax returned		0 18 0	
			18 5 9
North London Exhibition Trust—			
,, Balance, January 1st, 1918		19 8 1	
,, Interest on Investments		6 14 10	
,, Income Tax returned		1 12 0	
			27 14 11
Dr. Aldred's Trust—			
,, Balance, January 1st, 1918		13 19 6	
,, Interest on Investments		7 14 5	
,, Income Tax returned		1 18 0	
			23 11 11
Thomas Howard's Trust—			
,, Balance, January 1st, 1918		30 3 0	
,, Interest on Investments		19 19 7	
,, Income Tax returned		12 3 1	
		62 5 8	
Less Income Tax on Interest		5 7 5	
			56 18 3
Owen Jones Memorial Trust—			
,, Balance, January 1st, 1918		75 16 1	
,, Interest on Investments		15 13 4	
,, Income Tax returned		10 3 8	
		101 13 1	
Less Cost of Prizes and Medals	£ s. d. 19 2 6		
Income Tax on Interest...	4 6 2		
		23 8 8	
			78 4 5
Mulready Trust—			
,, Balance, January 1st, 1918		39 16 1	
,, Interest on Investments		4 15 0	
,, Income Tax Returned		2 15 0	
			47 6 1
Dr. Swiney's Trust—			
,, Balance, January 1st, 1918		160 0 0	
,, Ground Rents (Income from)		180 15 4	
		340 15 4	
Less Transfer to the Society's Income and Expenditure Account		140 15 4	
			200 0 0
Francis Cobb Trust—			
,, Balance, January 1st, 1918		19 12 3	
,, Interest on Investments		8 18 10	
,, Income Tax returned		5 16 1	
		34 7 2	
Less Cost of Professor H. R. Procter's Lectures	£ s. d. 20 0 0		
Income Tax on Interest...	2 9 1		
		22 9 1	
			11 18 1
Le Neve Foster Prize Trust—			
,, Balance, January 1st, 1918		1 15 5	
,, Interest on Investments		5 15 11	
			7 11 4
Fothergill Trust—			
,, Interest on Investments		13 12 5	
,, Income Tax returned		3 12 0	
		17 4 5	
Less Balance overspent, January 1st, 1918		9 2 3	
			8 2 2
Trueman Wood Lecture Trust—			
,, Interest on Investments			3 11 7
Cantor Trust—			
,, Interest on Investments		143 2 11	
,, Ground Rents (Income from)		141 0 0	
		284 2 11	
Less Transfer to the Society's Income and Expenditure Account		284 2 11	
			—
Davis Trust—			
,, Interest on Investments		78 2 8	
Less Transfer to the Society's Income and Expenditure Account		78 2 8	
			—
			£483 4 6
1919.			
Jan. 1. By Balance brought forward			£478 13 8

BALANCE SHEET, December 31st, 1918.

Dr.

	£ s. d.	£ s. d.
To Capital Account:—		
As on January 1st, 1918 ...	22,945 17 5	
Plus Income and Expenditure Account Balance	796 4 10	
		23,742 2 3
,, Bank Loan		1,900 0 0
,, Trust Funds:—		
Capital Account	15,233 18 2	
Accumulations under Trusts Income and Expenditure Account	478 13 8	
		15,712 11 10
,, Sundry Creditors		2,077 9 8
		£43,432 3 9

Cr.

	£ s. d.	£ s. d.
By Investments (see Schedule):— As on December 31st, 1917 (as valued at May 31st, 1917)		19,961 0 5
,, Property of Society (Books, Pictures, etc.)		5,000 0 0
,, Trust Funds Investments (at cost, see Schedule)		15,233 18 2
,, Ground Rents outstanding:—		
Trust Account	90 0 0	
Society's Account	162 18 0	
		252 18 0
,, Subscriptions outstanding		1,529 0 0
,, Sundry Debtors:—		
Journal	50 0 0	
Advertisements	15 0 0	
Repayment of Expenses for use of Meeting Room	89 5 0	
Income Tax recoverable	328 6 5	
		482 11 5
,, Cash at Bank on Current Account (less Cash in transit)		572 15 9
,, do. on Deposit		400 0 0
		£43,432 3 9

We have audited the above Accounts and Balance Sheet for 1918 *with the books, accounts, and vouchers relating thereto, and certify them as being in accordance therewith. We have verified the Bank Balances and investments.*

KNOX, CROPPER & CO.,
Chartered Accountants.

Spencer House, South Place, E.C. 2.
14*th June*, 1919.

SCHEDULE OF THE SOCIETY'S INVESTMENTS.

		£ s. d.
	Ground-rents (amount invested)	£10,496 2 9
£217 0 0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock ...	158 8 0
£500 0 0	New South Wales 4 per Cent. Stock	415 0 0
£500 0 0	Canada 3½ per Cent. Stock	360 0 0
£100 0 0	Queensland 4 per Cent. Stock	80 0 0
£530 10 1	New South Wales 3½ per Cent. Stock	456 5 0
£500 0 0	Natal 4 per Cent. Stock	400 0 0
£321 15 9	Metropolitan Water Board "B." Stock	196 6 0
£6 0 0	New River Company Shares	6 0 0
£3,000 0 0	Newcastle-on-Tyne 3½ per Cent. Stock	2,775 0 0
£3,408 14 6	India 3½ per Cent. Stock	2,317 18 8
£500 0 0	South Australia 4 per Cent. Stock	400 0 0
		18,061 0 5
£2,000 0 0	War Loan 5 per Cent.	1,900 0 0
		£19,961 0 5

TRUST FUNDS INVESTMENTS SCHEDULE.

	£	s.	d.
Alfred Davis's Bequest	£1,953	0	0
Mr. Swiney's Bequest	4,477	10	0
Mr. Cantor's Bequest	2,695	11	3
Mulready Trust	105	9	9
Howard Trust	571	0	0
Owen Jones Trust	522	3	2
Mr. Cantor's Bequest	3,273	16	6
	648	19	7
J. Murray and others, Building Fund	20	16	4
	38	11	0
Francis Cobb Trust	255	14	1
Le Neve Foster Trust	105	11	7
	42	2	1
John Stock Trust	70	4	0
Shaw Trust	93	12	0
North London Exhibition Trust	134	17	0
Fothergill Trust	272	7	6
Aldred Trust	154	8	0
Endowment Fund	394	7	0
"Trueman Wood" Lecture Endowment Fund	654	15	7

	£	s.	d.
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	£1,800	0	0
Ground-rents (amount expended)	4,477	10	0
Do. do do.	2,695	11	3
National 5 per Cent. War Bonds 1927	109	10	1
Metropolitan Railway 3½ per Cent. Stock	510	9	5
India 3 per Cent. Stock	423	0	0
Do. do. / Bombay and Baroda Railway Guaranteed 3 per Cent. Stock	2,573	10	0
India 3½ per Cent. Stock	20	10	0
5 per Cent. War Loan	54	18	0
New South Wales 3½ per Cent. Stock 1930-50	250	0	0
3½ per Cent. War Loan	100	0	0
5 do. do.	40	0	0
5 do. do.	100	0	0
5 do. do.	129	6	8
5 do. do.	184	15	0
5 do. do.	374	0	0
5 do. do.	210	17	6
5 do. do.	525	2	3
National 5 per Cent. War Bonds 1928	654	18	0
	£15,233	18	2

NOTICE.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Sixty-fifth Annual General Meeting, for the purpose of receiving the Council's report and the Financial Statement for 1918, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 25th, at 4 p.m.

(By order of the Council),

GEORGE KENNETH MENZIES,
Secretary.

"SPONTANEOUS COMBUSTION," Especially with reference to Ships' Cargoes. Coal, Charcoal, Cotton, and Textile Fibres generally; Hay, Tobacco, and certain Chemicals; Dyestuffs and Pigments, etc.

By WATSON SMITH, F.C.S., F.I.C.,
Formerly Lecturer in Chemical Technology, Victoria University, Manchester, and, later, Professor of Applied Chemistry in University College, London.

So-called "spontaneous combustion" arises by reason of such chemical and physical changes in bodies mostly consisting of, or containing carbon (carbonaceous substances), and under the influence of atmospheric oxygen, that sufficient heat is generated to give rise ultimately to combustion.

In order that the heat developed shall accumulate, and not be carried off by the surrounding air or other media, the matter inclined to "spontaneous combustion" must, as a rule, be a bad conductor of heat. Molecular changes by disturbance of the equilibrium of the smallest integral particles, mechanically fine subdivision of particles, moisture, and external heat, play the most prominent part, in the case of easily oxidisable substances, in the generation of this so-called "spontaneous combustion." With rising temperature, naturally, increased oxidisation rises *pari passu*, and increases until the combustion point is reached.

The most frequent cases of "spontaneous combustion" occur in coals, and not many years ago the German Government, after an elaborate inquiry, declared that more ships were lost through such outbreaks on board ships than through any other cause. In coal, besides the carbonaceous matter, we meet frequently with compounds of sulphur and iron (pyrites), also combustible gases, carbides of hydrogen ("marsh gas"), occluded in the mineral. The hydrogen carbide escapes from the broken mineral during transport, especially when it is discharged, or "shot," into the ships' holds, or even during movements of the vessels, and mingled with eight to ten parts of air it forms a highly dangerous mixture, igniting in contact with a spark or open light, and giving rise to explosions. There are two iron and sulphur compounds found in coal,

often scarcely visible, but just as often penetrating the mass of the coal through and through, and shining like brass. The one is ordinary iron pyrites, FeS_2, with 46·67 per cent. Fe and 53·33 per cent. S; the other is Markassit (or Marcassite), FeS_2+FeS. Both compounds are gradually decomposed in the air and by the action of heat, the oxidation being aided and hastened by the presence of moisture. Of the two varieties, Markassit is the more dangerous, as it decomposes most readily in presence of air, moisture, and heat.

In coal deposits, so much heat is generated by the process of decomposition of Markassit ($FeS_2 + FeS$), that the small coal takes fire, with great risk to the entire deposit. The greater or less danger of coals from different mines depends greatly upon the kind and proportion of these pyrites, in which the Westphalian is usually richer than the British coal.

Certain mines, like those of Cardiff and Wales generally, the coals of which are comparatively free from pyrites, are most suitable for shipment, whilst of those from the east coast of England the West Hartley Main coals are most prized.

The good reputation of these coals must not, however, be pressed too closely, since other and even neighbouring mines may be as dangerous as any. For example, the Garn mine, in Wales, has had a long and evil reputation for dangerous coal. Hence careful and skilled examination and testing are necessary, and it should be the aim of authorities, after due inquiry, to exclude such coals from shipment, because of the great danger to human life.

When Liebig was consulted on the subject of the frequent disasters in the case of ships laden with coal, he quickly traced the reason to the fact of the presence of pyrites and the further fact that the presence of air and water can easily act on such coals. He recommended that coals should never be shipped in a damp or wet state, or during rain.

Coal in large lumps is far less dangerous than small coal or slack, which offers more surface to air and moisture. It would be useful in loading up the coal on shipboard to sprinkle or spray it in layers with coal-tar, thus more or less excluding air and moisture. Numerous examples of terrible disasters directly traceable to "spontaneous combustion" in the case of ships at sea are available both as regards this country and America, as well as Germany and France.

Personally, I dislike the term "spontaneous combustion" since it involves the assumption of no cause, and every effect must have a cause. A "combustion mystery" I could understand, since until investigation has disclosed the hidden cause, the element of mystery exists. But "spontaneous" is a word savouring too much of the superstitions of the Middle Ages! L. Häpke states that of all the shipments of coal in 1874, the huge proportion of disasters by fire was with those vessels laden with coal for the tropics, and it was proved that the percentage of such losses rose with the size and weight of the cargoes.

Above all things, the breaking up of the ship-laden coal should be avoided, for not only is the value of the coal diminished, but danger is increased through increase of surface, and in most methods of shipment the small coal and rubbish collects just under the great hatchways, and it has been proved that most outbreaks start there.

We may say then that, generally, so-called "spontaneous combustion" is caused by the physical and chemical capacities of certain carbonaceous and organic matters to condense on their surfaces gases and moisture. The amount of gases thus condensed varies with the chemical nature of the gas, and is also dependent on the degree of subdivision of the absorbing substances. If the atmospheric oxygen is the gas thus condensed, evolution of heat accompanies the condensation, and if this occurs within a bad conductor of heat the latter accumulates and eventually gives rise to combustion.

The fact then, that coal containing, distributed throughout its mass, pyrites, is most inclined to fire when in a damp state, should lead shipowners and insurance agents to insist on certain precautions; such, for example, as observations of temperature at certain periods and in different parts of the cargoes—these to be strictly recorded for reference in the ships' books and as a matter of law. Likewise, in cases of outbreaks in mines, each case ought to be duly recorded, and the names and positions of such mines to be available for any shipowner or exporter, and as a strict matter of law; and I say this all the more firmly after perusal in the papers recently of a cross-examination of Mr. Sidney Webb, himself a Commissioner, in the Coal Inquiry of April 30th, 1919, with regard to nationalisation and its economics, etc. Asked if he found any colliery managers favourable to the idea of nationalisation, he said he did "not find them with any ideas at all!" He

added: "It is one of the great evils of the existing profit-making system in coal-mining, as in other industries, that the practical men are shockingly destitute of ideas." He added: "I am making a serious indictment against the system of profit-making. . . . When it is cheaper to compensate for accidents than to prevent them, it necessarily lessens the stimulus to prevent them." Asked to state upon what facts, to his knowledge, he based his indictment, he said: "The experience of insurance companies, mutual funds, etc.," and he added that "the number of casualties in the coalmines last year (1918) exceeded the whole number for the Gallipoli campaign."

The observations noted above and advised as a matter of strict law and justice have, says L. Häpke, been avoided or neglected in many cases, if not generally. It must be remembered, he says, that the height or depth of the coal layer only favours the accumulation of heat in the interior parts, so that the danger of incipient combustion is increased, and thus the danger is all the greater in the case of the larger ships.

Döring insists, with regard to coal cargoes and their inspection, that this inspection should only be made with the aid of a reliable safety lamp. The flame of such a lamp, in presence of only 2 per cent. of gas, shows a blue cone, and increases in size considerably in presence of 3, 4, 4½, and 5 per cent., until with 5½ per cent. the whole globe or lamp is filled with flame. Coal-fires due to "spontaneous combustion" were first observed at Brest (1757), and on board the "Maria" at Kronstadt (1781). In the latter case, the fire was found to have been started by a mixture of linseed oil and soot.

Explosions of four gunpowder factories within a short space of time, in the beginning of last century, were due to "spontaneous combustion." Liebig in 1866 was the first to demonstrate the liability of coal containing pyrites to combustion. Abel and Percy confirmed this observation in 1876, and recommended *frequent observations of temperature.*

Air-shafts through the masses of coal on board ships, for the purpose of ventilation, were found by sad experience actually to favour the tendency to outbreaks of combustion, for of four vessels carrying coal to India, three thus well ventilated were lost by fire outbreaks, whilst the fourth, not thus ventilated, reached its destination in safety. Firing of coal-stacks on land not unfrequently occurs, not to speak of firing in the mines. The height of a coal-stack ought not to exceed 2·5 metres.

Explosions of Coal Gas.—These are never "spontaneous"; there is always a direct cause. The gas which in ships' cargoes and in mines may plead guilty of such occurrences is a mixture of about one-tenth marsh gas, or gaseous hydrocarbon, and nine-tenths air. This mixture, which is only fired by a light or spark, is all the more dangerous because it possesses no odour, and its properties are little known. Of course, the passing of air for ventilation through such masses of coal just favours the formation of the dangerous mixture aforesaid.

The only way to diminish the danger of explosions is to be found in surface ventilation, by passing a current of air directly over the coal, and leading it directly into the open. The extinction of burning cargoes of coal by means of carbon dioxide the British Commission of inquiry about 1890 held to be impracticable, as this gas has no cooling effect. The Commission was far more inclined to favour the employment of water and steam in cases of large masses of burning coal.

According to the ruling of the Bremen Chamber of Commerce (1888), the Director, Dr. Romberg of the Russian Commission, recommended that educational steps should be at once taken both for warning and instruction of officers and sailors, so as to avoid such disasters, or at least to diminish their number; a printed guide-book of instruction should be distributed gratis amongst all concerned, as also in the navigation schools, and adopted in all nautical examinations.

It was recognised by this Commission, which had consulted Liebig in 1866 on the subject, that such disasters did not arise through ill-will or neglect, but much rather through *sheer ignorance.* Nevertheless, a comparison with Great Britain demonstrated a decided advantage as regarded transports of coal by ship in favour of Germany. (This "Anleitung," dated 1889, was published in Berlin by the "Reichsamt des Innern.") Can we, in this country, not do something of the kind, if only to avoid the need of such invidious comparisons?

Let us now ask ourselves the question: "Do these disasters continue still as merrily as ever, and is the subject still beneath the same shadow of ignorance?"

I will answer it by a few up-to-date quotations. But I must first refer to the fact that so long ago as 1874 it was observed that in that year, out of a total of 31,000 coal shipments, 1,184

were to far distant ports, and in more than 4 per cent. of these cases fires broke out, with a total of 70 complete disasters by losses of ships and cargoes. Of these 70 losses only 10 occurred during shipment to European ports, whilst 60 occurred *en route* to Asia, America, and Africa.

First appears a "mine fire" (April 2nd, 1919), at Maxwell Colliery, six miles from Girvan. Two miners killed. Fumes from the disused mine close by, which "took fire" nearly a century ago, worked their way through to the Maxwell pit, and work was suspended. The next day two men descended to start the pumps and were killed. The site of the old mine is known as "the burning hills," and jets of steam and gases, killing all vegetation, are emitted. From a scientific point of view this is a gross scandal. The "taking fire" of pit No. 1 demanded a strict scientific inquiry, and does still—not to speak of the "Maxwell Colliery."

Second.—In the papers about May 21st last, I learnt that the Dutch steamer "Volkraet" had been found derelict and burning about forty miles south of St. Catherine's Point, Isle of Wight, and had been towed into Portsmouth for repairs. The crew had been taken off and landed at Deal by the Spanish steamer "Favoritino." The "Volkraet" was loaded with nitrates. Let us imagine moisture in the "nitrates," or having access thereto: such moisture, more or less saturated with dissolved nitrates, if gaining access to coal on board, in the bunkers, would soon cause heating, the nitrates would dry up, and with coal or coal-dust, form a mixture approaching gunpowder in character.

Third. — Here is a very probable case of "spontaneous combustion" of coal on board a steamer. The item is headed, "Burning steamer—abandoned by her crew in the Atlantic." British steamer "Penlee," on fire fore and aft, had been making her way to Queenstown. She sent several messages, one stating that the fire was gaining, and it was uncertain how long steaming could continue. The report shows every evidence of mystery overhanging the cause of the outbreak, which simply accentuates the suspicion of "spontaneous combustion." (Date of report, March 21st, 1919.)

Fourth and Fifth.—Both reported in the papers for March 25th, 1919: (*a*) *Burning Ship Mystery.* Unknown steamer in flames off Lundy Island. Was observed on fire at 9.15 p.m. on Saturday, 6 miles to the N.E. She drifted south of the island, and was last seen at noon yesterday (March 24th, 1919), 12 miles W.S.W. (*b*) *Belgian Ship on Fire.* Message from Flushing stated that the steamer "Wilfred" was on fire off West Kapelle. Four of the crew were landed.

Here, then, is a fair output of risks to human life for the brief period involved, not to speak of loss and destruction of property. But the cases minutely given, and covering a considerable number of years, by Häpke, Döring, and others, with more minute details of awful suffering and loss, form a terrible indictment against any who prefer profiteering to due and properly organised scientific observations and precautions accompanied with strict legal enactments. As against the five cases I culled and have cited from the papers on dates so near together, we may ask how many more exist as "unknown catastrophes," and never will have any record?

Attempts to extinguish coal fires on board ship have been made with liquid carbon dioxide, first by an American, Lieutenant Barben, in 1874, who drew attention to the method. Later, David Stewart, of Dundee, experimented with it, and for a time it was recognised in this country as an efficient agent. It was to be used in an automatic form as a bomb or cylinder filled with the liquefied CO_2, and closed by means of a stopper of Wood's fusible metal. However, it was soon found that the outrush of gas was such that cold was frequently produced sufficient to solidify the carbon dioxide, which then appeared like ice-crystals or snow, and a fall of temperature took place of more than 70° C. The solidified gas soon stopped up the tube, and the automatic action was brought to a standstill. Nevertheless, as Häpke suggests, the matter is worthy of further experimental inquiry and testing, though he points out, as one of the difficulties in the way, that such outbreaks so often take place where least expected. But I reply, "What of scientific observations?" and again, "What of human life?"

In the case of brown coal and lignite, combustion outbreaks do occasionally occur, but only occasionally. Here again observations are necessary.

Quicklime.

Häpke states that though seldom occurring, fires may arise through accidental contact of water with stocks of quicklime, and he records a notable case at Celle, in Germany, about the year 1860, when the heat thus generated set on fire neighbouring heaps of straw and hay. Singular to say, just after reading the passage

quoted, my eye caught the following one in an evening paper (dated March 10th, 1919):—"Rain, acting on quicklime, caused a fire at the store of Messrs. Passmore, Roberts and Co., cement merchants, Stepney, this day." That is nearly sixty years after Häpke's observation in Germany. Needless to say it could not have been the lime that took fire, but must have been a case of too close proximity to some carbonaceous and inflammable matter.

Charcoal.

Aubert found that finely-ground charcoal placed in a barrel attained a temperature of 75° C. after fifteen hours; after twenty hours, ignition took place. The charcoal was found to have absorbed oxygen and a certain quantity of water. Having once had the management of a wood-distillery, I can testify to the need of great precautions to avoid the danger of outbreaks of fire in the charcoal sheds. Water is always used to quench the hot charcoal after raking it out from the ovens and shovelling it into the underground vaults, just before letting down the lids upon these vaults; and I can easily conceive that the addition of a certain excess of water might cause eventually a tendency to rise of temperature in the charcoal, albeit perfectly cold when raised from the vaults and wheeled to the sheds where it is stocked. In the two or three years I had charge here, there were two outbreaks of fire, promptly quenched, the stocks not being large in each shed. From all I could gather, it appeared almost like caprice that the charcoal in most cases kept cold, and yet on the single occasions referred to would heat up even to redness. Doubtless a slight counterbalance of moisture was the apparently capricious cause.

Cotton.

The statement that wet cotton is liable to break out in combustion is improbable; but a spark getting into a bale will smoulder for a long time, and the fire eventually occurring will then be probably stated as due to "spontaneous combustion" (see also p. 507). Greasy cotton is undoubtedly dangerous, most fatty oils absorbing oxygen rapidly with generation of much heat. In cotton mills, the periods between Saturday afternoons and Monday mornings specially call for watchfulness. The few cases of "spontaneous combustion" of wool, flax, jute, or oakum, were also due to these materials being impregnated more or less with oils, varnishes, or certain dyestuffs.

Silk.

Heavily weighted silk is dangerously liable to heat up and burn, one case being recorded by Persoz, and another occurred on board ship.

Haystacks.

The firing of haystacks, though frequently disputed, is an undoubted fact, established by Ranke at the suggestion of Liebig. The heat in the stack was found to rise to 300° C., the hay being finally converted into a voluminous mass of char. Cohn showed that fermentation in hay and caused by bacteria, is responsible for such occurrences, and in Holland a preventative is found in common salt, which is scattered between the strata of hay in the erection of the stacks. For the same reason the stacks are built with an air-shaft in the centre. Based on observations made in the drying of medicinal plants, Tschirch (*Schweiz. Chem. Zeit.* 1919, 2. 10–12) advances the following theory to account for spontaneous combustion in haystacks. He regards the first phase of heating as due to oxidation processes caused by the plant oxidases and at the expense of the air present in the stack, resulting in a small rise of temperature, which ceases when the oxygen present in the stack is exhausted. In the next phase the chief *rôle* is played by reductases, which act energetically between 50° and 70° C. and effect the deoxidation and eventual carbonisation of such substances as amino acids and carbohydrates. The danger of ignition is due to the accumulation of oxygen withdrawn by the reductases, since the reduction processes themselves would not produce sufficient heat to ignite the material. To prevent "spontaneous combustion" of stacks, Tschirch recommends thorough drying of the hay before stacking, a process designed to minimise enzymic action, and thorough aëration of the stacks. This may be achieved by building them in horizontal layers with air spaces between.

Tobacco.

Fermentation is frequently the cause of combustion in the case of tobacco. A case was reported in the papers on May 13th, as follows: "A great fire has broken out in a tobacco warehouse at Cadiz, and two million kilogrammes are burning. It is feared the flames may spread owing to the strong wind now blowing."

Lupulin.

In 1893–94 a case of the "spontaneous combustion" of lupulin, an extract of hops, was

observed. Lupulin is used as a stimulant, and for insomnia, etc.

Aniline Dyestuffs, Lakes, etc.

In 1888, Hirsch observed that when the acid for nitration of benzene was passed through the S-tube, through which by mistake toluene had been allowed to run, the acid instantly became hot, and white vapours arose. A workman in this case tore out the tube, and as soon as he had thrown it away combustion broke out. Similar combustion may also arise if the agitator does not work when the acid for nitration runs into the apparatus. This unagitated acid falls to the bottom of the vessel, and when later on the agitator begins to work again, the violent chemical action ensuing raises sufficient heat possibly to lead to combustion, and if several vessels are connected together the effect may become one of explosion (*Journ. Soc. Chem. Ind.* 1888, 563).

Arlsberg, of New York, relates cases with the beautiful lakes of lead and eosine (tetrabromofluorescine). These lakes have been very extensively used, and especially the mixtures with red lead (Pb_3O_4). Owing to their comparatively low price, they had supplanted in 1895 the mercuric sulphide and vermilion, and hence are known as "vermilion substitutes." On three different occasions, Arlsberg says, such mixtures of red lead and eosine took fire during transference from one cask to another. In vain did he seek for an explanation, although once he suspected a burning cigar or match to have caused the fire, but he could prove nothing, all the less as it was impossible to save any of the contents of either barrel owing to the extreme rapidity of the combustion.

When the second case of combustion occurred, Arlsberg failed to trace the cause to the use of either cigars or gas-pipe (used for stirring), but discovered that a burning gas-jet about five feet away from the barrel was guilty. The lake in question is very liable to raise a dust, whenever exposed to a very slight draught, which dust readily fired at the gas-jet. The Pb_3O_4 acted as a carrier of oxygen, and the combustion, once started at the gas-jet, set the whole case on fire with lightning rapidity. Since illumination by electric light had been established no further trouble arose.

The rapidity of combustion with such lakes (in the above case 95 per cent. of Pb_3O_4 with 5 per cent. of lake) is equalled, if not surpassed, says Arlsberg, by that of the ferroferricyanides of iron, which frequently take fire when being powdered. In such case a spark, generally produced by a bit of iron (a nail), is the cause of ignition, the atmosphere furnishing the oxygen.

Endemann and Stebbins reported cases of combustion of copper and iron-lakes of logwood, for which they could not account (*Journ. Soc. Chem. Ind.* 1895, 947).

Zinc Dust.

L. Häpke records a serious case of zinc-dust firing, fully reported in the *Pharm. Centralhalle* of May 24th, 1877, which occurred at Liverpool. In outline it was as follows:—

On December 11th, 1876, twenty casks of so-called "zinc-dust" were shipped on board the "Lord Clyde" steamer. They were declared to contain "Dyestuff," and bore a ticket marked "To be kept dry, as, if damp, liable to get hot." Nothing was stated as a warning against liability to outbreak of fire or incandescence, etc. The casks were taken on board and lay there all night. Next morning a "smell of fire" was noticed, showing that something was burning on the ship. When the fire was extinguished, it was proved that it had arisen in the immediate vicinity of each cask of zinc-dust, and had injured or destroyed various goods stowed away upon or near these casks.

Later on it was discovered that most of the casks, before shipment, had lain upon the quay, and one of them was decidedly damaged. A portion of the contents had fallen out, and had got damped by rain. In this case the damaged cask had been filled up, the cask repaired, and then shipped with the rest.

Subsequently, the source of the fire was closely examined, and it was discovered, through the evidence, that the contents of this one cask were red-hot. The Court decided, after full inquiry, to confiscate the cargo and subject the would-be exporters to summary punishment. Ordinary commercial zinc-dust is a grey and very fine powder, consisting of 40 per cent. Zn, $2\frac{1}{2}$ per cent. Pb, 4 per cent. Cd, 50 per cent. ZnO, and $3\frac{1}{2}$ per cent. $ZnCO_3$. Because of its very fine state of subdivision, the metallic portion becomes oxidised very rapidly in presence of moisture, robbing the latter of its oxygen and liberating considerable quantities of hydrogen. Such zinc-dust is in great request in dyestuff works.

Fire-lighters.

In 1890, Tatlock (*Journ. Soc. Chem. Ind.* 1890, 1112) stated that a fire broke out in a workshop in Glasgow, where fire-lighters were made from a mixture of sawdust and melted rosin. The

following day some of the finished goods that had escaped were taken away for investigation. One pound weight was placed under a glass shade with a thermometer, and in less than an hour the substance burst into flame. An examination of the sawdust used showed that it contained a large proportion of moisture when mixed with the rosin, and further experiments confirmed the view that this was the cause of the accident.

Dried Fish, Guano, Bone Dust, etc.

Tatlock records the fact that a few hundred tons were landed from a ship at Glasgow, and at once placed in bulk in a store on a stone floor. In a short time the material began to heat internally, and so it was opened out and spread more thinly over the floor by a gang of men (of course bringing the heated stuff more in contact with the oxygen of the air). Whilst this spreading out was taking place, a large quantity of the material took fire, and before extinction could be effected a portion of the enclosure was destroyed. Tatlock's further experiments with coals, oils, etc., are very interesting. (*Journ. Soc. Chem. Ind.* 1890, 1112–1114.)

Dr. Weigelt, of Berlin, in 1890, was eye-witness to a case in which a fish powder of sticklebacks had been manufactured for feeding pigs, and only contained 1 per cent. of fatty matter. A mass of this material began to heat up and reached the point of combustion. Döring mentions the cases of fire outbreaks on two ships laden with bone-dust. One reached its destination, but was destroyed; the other began to burn when near Falmouth, and the fire could only be extinguished by sinking the ship!

Chemicals.

Amongst the acids the most dangerous are sulphuric acid and nitric acid. As ships' freights, the carboys in hampers and straw should be stored with great care, and enclosed either under deck or on deck with sand, so that, anyhow, when the safety of the ship demands it, they can be readily pitched overboard. The schooner "Thetis," of Barth, was laden in Hamburg with sulphuric acid, and, along with various solid goods, also a quantity of nitre! The acid proved to consist of a dangerous mixture of 75 per cent. of sulphuric with 25 per cent. of nitric acid. With this pernicious cargo the captain put to sea on December 1st, 1888, at Cuxhaven. When, on December 13th, smoke was observed in the ship's hold, the captain pulled up near Plymouth where the fire was got under by steam-jets. Shortly after, the crew abandoned the vessel, and then four or five violent explosions occurred, which reduced the burning schooner to matchwood. Similarly the steamer "Oscar," bound from Hamburg to Spain, had on board some carboys of vitriol, one of which leaked. A fire arose, and nothing would extinguish it but the wholesale inrush of sea-water, which means the ship had to be sunk!

Spontaneous ignition of mixtures of air and ether vapour. *Comptes rend.* 1919, clxviii. 729. E. Allaire has studied the conditions under which air and ether vapour mixtures may ignite, and he used a special apparatus by which the proportions of the two gases could be varied as desired, and properly measured. The gaseous mixture was led into a U-tube, one limb of which was furnished with points like a Vigreux tube, and having an opening through which a thermometer could be introduced into the bend. The whole tube was then immersed in an oil-bath. Various catalysts, such as oxides of iron, copper, nickel, etc., were tried, but they were apparently ineffective, though the mixture of itself ignited "spontaneously" at about 190° C., when the amount of ether present was about 1 grm. per litre. The flame was pale blue, and visible only in the dark, and the products obtained were ethyl and methyl aldehydes and carbonic and acetic acids. No reaction took place before the ignition. This phenomenon explains the occurence of accidents in factories and workshops in which ether vapour may diffuse accidentally. The author suggests the possibility, by modifying the conditions of the experiment and the use of tubes of greater diameter, of causing ignition at lower temperatures than the above.

Cotton.

According to a communication from E. Ellinghausen, the firm of F. W. Grüner & Sons received a consignment of Indian cotton damaged with river-water, and it was offered to the public by auction. On the auction day the cooper observed that a number of bales had burst several of their encircling iron bands, and the heating of the cotton was perceptible. Investigation showed that these bales contained an extraordinary proportion of cotton-seeds. The germination of the seeds in the bales could not proceed, but the heat had not quite reached the point of combustion.

In Liverpool, March 27th, 1893, a fire broke out—the fifth in a quarter of a year. Two cotton sheds of the firm of Rigg & Co. were burnt to the ground. A few days previously the cotton-spinning mill of Thos. Rivett, of Stockport, was burnt down, the cause of the fire being involved in mystery (see p. 504).

WOOL.

By too strong pressure and unnecessary storage in heaps, wool may heat up and cause danger. In one case in Buenos Ayres fermentation had thus ensued, and proceeded with rise of temperature until the material was carbonised. This dangerous action occurs also on shipboard occasionally. The following is a well-authenticated case: The British steamer "Cheshire" met, on its way from the Cape of Good Hope and before arriving at Las Palmas (Canaries), the three-master "Corintho," which carried a cargo of wool to bring to England from Tasmania. The crew had been struggling with a fire raging on board for five days. This fire had broken out in the wool cargo and resisted all attempts to extinguish it up to the time of arrival of the steamer, when fortunately the men were saved, and the ship and its burning freight abandoned.

MONTENEGRO.

By CAMPBELL D. MACKELLAR.

The economic resources of Montenegro and her position after the war cannot be ignored and have to be considered. The position of the country on the Adriatic makes communication easy and direct, and facilitates the import and export of goods. From information furnished by the Montenegrin Government, one learns that the country possesses 200,000,000 cubiques of timber ready for immediate exploitation. The trees include rare specimens, and are all suitable for industry. The olive groves on the coast, with those in Corfu, contain the oldest trees in Europe. The oil has been celebrated since the days of the Romans for its quality, and from the *débris* it is thought that a paying industry in soap and candles could be developed. The same district is adapted for the cultivation of the mulberry and silk-weaving.

The tobacco grown in the country equals that of Macedonia, and the cigarettes universally smoked throughout the country are excellent in flavour and quality, and well worthy of export.

The forest regions of the north-east give the best pasturage in the Balkans; skins, meat, and wool are the principal products. The Austrians, during the occupation, exported 11,000,000 kilogs of wool and a large quantity of hides. The wool is of fine and silky texture. It would be very desirable to see a technical school for the teaching of weaving and making of carpets introduced, as in Bulgaria, at Pirot, and elsewhere. The use of the smaller looms in the homes of the people would supply local wants, but technical education to produce skilled weavers is necessary. The wool has the same quality of a fine natural lustre as that in Bulgaria, and this in carpets retains its qualities.

The women spin and weave incessantly, but for home use. The quality of their homespun garments, especially of the pleasing creamy white, a feature of all costumes, is lasting and good. Could, even on a small scale, these homespuns be introduced to foreign markets, and their output stimulated, it would be a boon to the people. In combination with the production of fine wool, which, like that of Bulgaria, may equal Persian wool, the cultivation of the silkworm in the districts so well adapted for the mulberry would supply native silk for carpet-weaving.

The mineral resources of the country are undeveloped, and where the mines are situated there is abundant and handy water-power. White oil, iron, tin, and silver, are found, and in places traces of gold, but the mineral resources must be investigated and reported on by experts. The waterfalls surpass in power those of most other places in the Balkans. They attain to a mean of 50,000 h.p., and in places to 90,000 h.p., and the country is well supplied with water-power for agricultural purposes and the needs of electricity.

The fisheries of the lake of Scutari and the Borgana River are productive. The regularisation of the Drina and Borgana Rivers will lower the level of the lake, restoring to cultivation thousands of acres of fat lands now submerged and lost to the people. The wide plain of Vir Pazar, on the Lake of Scutari, resembles part of the lake, turning Vir Pazar itself into the semblance of an island joined by bridges to the land on either side. Vir Pazar is the terminus of the only railway in the country, that from the port of Antivari; but many railways are projected, which, if built, would change the aspect of the whole country. A line is projected joining Podgoritza, the largest town, with Kolachine, in the line of the Moratcha-Kolachine-Biélo-Polié; Plevlie, with the east

line in Bosnia; from Kolachine by Andriyeritza, Berane, Novi-Pazar, with the Serbian system; from Andriyeritza by Plav-Petch to Mitroritza in Serbia; Petch to Djakoritza and Sulia; Podgoritza - Nikchitch - Trébigné for Herzegovina; Nikchitch, by the Piva and Folctra, for Bosnia; and Podgoritza, Scutari, and the Adriatic.

The beauty, interest, and charm of the country inland, as on the sea, will in time make it a pleasure haunt of Europe, and the coast, especially when Montenegro has the free use of her beautiful harbour of Cattaro, will become a new Riviera, abounding with hotels and villas. Given peace, and aid in reconstruction, there is nothing to prevent Montenegro becoming a most prosperous land. The roads in the country, so far as they go, are excellent, and traversed by motor post omnibuses.

Montenegro has, like other lands, to enter upon a new era, her days of battle glory over, and her position on the sea gives her great advantages. The sooner attention is turned to her needs and resources the better. As many Montenegrins have been working in mines and other employments in Canada, South Africa, and other overseas places, and these men have in many cases fought in the ranks of our overseas forces during the war, they are acquainted with our ideas, long for intimate friendship with us, and many speak English.

ALCOHOL AND COLD.

By Josiah Harding, M.Inst.C.E.

During the past fifty years a great amount of knowledge has been accumulated respecting the action of alcohol on the human system. Part of this knowledge has been derived from scientific investigation and part from practical experience combined with more or less scientific experiment. It has therefore been to me a matter of some surprise to see that the results of this accumulation of data have been and are being daily ignored by writers who, whether from ignorance or carelessness, give advice which must lead to most disastrous consequences. I therefore think it may be of value to recall a few of the most striking of these results and to supplement them with some facts from my own experience.

The data to be obtained from some assurance societies, such as the Temperance Provident Institution, extending over a period of about one hundred years, show that the death-rate of moderate drinkers is more than 40 per cent. greater than that of total abstainers (of course, the society does not take knowingly any heavy drinkers). This 40 per cent. is too large a proportion, and the period too long, for this to be due to accidental coincidence. The result of a careful study of the matter, based on data supplied from many countries, leads one to the following explanation.

(*a*) A total abstainer is almost of necessity a person of orderly conduct and habits, and is therefore less liable to accident and to indulgence in acts tending to shorten life.

(*b*) The result of careful observations by medical men and other patient observers in all parts of the world shows that the habitual use of even a small amount of alcohol, say only wine and beer, renders a person more liable to contagion than if he were a total abstainer, and is in many cases a great hindrance to recovery. This is especially so in the case of tuberculosis and some forms of venereal disease.

(*c*) In an abstainer flesh wounds will, as a rule, heal more rapidly and better.

(*d*) The very popular but erroneous belief that a nip of spirits will "keep out the cold."

This aspect of the question, from its great importance, I will treat more fully, especially as it seriously affects the well-being of our brave soldiers and sailors. One does not require to drink spirits to know that imbibing alcohol in almost any form will produce a certain glow of heat on the *surface* of the body, and hence the very natural idea that it *produces heat.* I believe that the first occasion on which this idea was called in question was during the celebrated and disastrous retreat of Napoleon's grand army from Moscow. Some of the French doctors remarked that certain Italian soldiers withstood the cold better than their companions, *in spite* of the fact that they refused to drink spirits. Now some of the doctors suggested that the resistance to cold might be *because* they took no spirits.

In after years, many people whose business subjected them to exposure to severe cold found that if they drank spirits before or during the said exposure they suffered far more severely than if they took nothing, but that a glass of toddy was good to hasten the return of warmth *after* they got home and knew that they had not to expose themselves again. This was corroborated by those who had to sail the stormy seas, where it became a regular institution to serve a tot of rum *after* reefing topsails in cold weather.

There was thus developed a certain difference of opinion or subject of discussion which induced the Royal Society of Arts to commission Dr. Benjamin Ward Richardson (who was not then a teetotaller) to deliver a series of lectures on alcohol. To prepare data for these lectures the doctor made a most careful and thorough study of the subject, including many experiments on animals and on the human subject. The results of these investigations were embodied in four lectures delivered before the Society in 1874.

In general the outcome of Dr. Richardson's experiments showed that the drinking of alcohol caused a flow of blood to the surface of the body,

through the relaxation of the muscular coatings of the capillary blood-vessels, with the result that exposure to cold was followed by a very appreciable *lowering* of the temperature of the body.

In fact Nature causes these muscular coats of the small blood-vessels to contract under the influence of cold in order that the heat of the body should not be too readily dissipated, whilst the action of alcohol is to reverse this wise provision of Nature and to throw the heat outwards on to the surface, to be carried off by the cold air or wet surrounding the body.

It was also noticed about this time that drunken men locked up all night in a cold cell were sometimes found dead in the morning, although as was supposed they had plenty of alcohol inside "to keep out the cold."

Then came the feat of Captain Webb. In his first attempt to swim the Channel, at the insistence of his own backers, but against his own opinion, he was supplied with brandy, beaten up with an egg, at intervals on the way, which caused his temperature to fall so rapidly that he was obliged to give up the attempt. On the second trial, during which he refused to take brandy, he was easily successful, arriving at the French coast with a wonderfully small loss of temperature.

These events occuring very near together in point of time induced the British Admiralty to charge Captain Nares (afterwards Sir George) to study the matter during the voyage of H.M.S. "Challenger" to the Arctic seas, which he was then about to undertake.

With this object the ship's company was divided into three classes of about equal numbers, first total abstainers, second those who were to consume the regulation quantity of alcohol, and third a section allowed to take as much liquor as they liked, short of intoxication.

This experiment gave the most positive proof that the more alcohol a man consumed the more he suffered from the cold, and that some of the men who had *never* taken any alcohol withstood the cold best of all.

In the recent South Polar expeditions of the unfortunate Captain Scott and others the result has been the same. In the report of a branch expedition to visit the magnetic pole, the writer of the report says that they celebrated Christmas Day by drinking wine, and that in consequence they all suffered *for some days* from reduced temperature to such a degree that they vowed never to give way again to this temptation.

Now for my own experience. I have been engaged on railway surveys and construction for more than fifty years, during which time I have held the post of chief engineer on three important railways, including two transandine lines, and have had at times more than three thousand men under my orders. I have been through severe epidemics of small-pox, Asiatic cholera and bubonic plague, besides having experience of many cases of typhoid fever and dysentery. During the cholera period I had frequently to visit infected camps, and the doctor always urged me to fortify myself with a good drink of brandy before each visit, which I consistently refused. I have slept hundreds of times in regions in which fever was endemic and was the only man to escape immune.

When over sixty years of age, in andine expeditions in company with young and robust men, withstood the cold and the mountain sickness better than any man of the party.

I have slept out at night at heights up to 17,000 feet and with a temperature as low as 25° C. below zero and I have never tasted any alcoholic drinks in my life.

During the construction of the Antofagasta and Bolivia Railway I made, as usual, every endeavour to keep the men from drink, but this was not always possible. At a town called Calama, at 7,500 feet above sea-level, we suffered heavy loss through mountain pneumonia. Between the railway men and miners from the surrounding district there were 600 deaths during the five winter months from this cause. This was the usual course of events: A man would arrive in the town from the mines or the railway camps, go into a liquor shop and pass the time drinking, card-playing, etc., until he would be turned out about midnight, when he would perhaps retire to his lodgings, or still worse sleep in the road wrapped in his thick woollen poncho; in the morning he would awake with pneumonia and generally in two days he would be dead. Of course these men were accustomed to sleep out like this as I was myself, and when there was no liquor they did so with perfect impunity.

The evidence showing the danger of drinking spirits, or even strong wines, before or during exposure to wet or cold is quite complete and incontrovertible; but there is a point which requires further investigation, and that is, How soon after drinking will it be safe for a man to be exposed to cold?

I believe that even a small quantity will impair his resistance to cold for more than twenty-four hours, and this is borne out by the experience of the magnetic pole expedition referred to above, in which their Christmas wine reduced their temperature for some days. Large doses may even affect a man for weeks or months, and in extreme cases become permanent, as witness the red face and especially nose of a drinker; but this is a matter which is worthy of scientific experiment.

WATER-POWER IN ICELAND.

The available water-power in Iceland is considerable, and capable of great developments. The greatest waterfall, on the River Dettiloss, belongs to an English company, says the *Teknisk Ukeblad*, and has a fall of 300 ft. estimated to produce 220,000 h.p. The principal glacier-fed Icelandic river is the 124-mile long Thorsa River, which discharges nearly 18,000 cubic ft. of water per

second during summer, reduced to 9,500 cubic ft. per second during winter. There are no fewer than six falls, from which 1,114,000 h.p. can be obtained during the seven summer months. Only 697,000 h.p. are available in winter, but the mildness of the climate prevents any difficulty with ice.

The estimated cost of harnessing this power, basing on 50 per cent. above pre-war prices, is £11 9*s*. per h.-p. unit, and the estimated net cost per h.p. year 10 per cent. of this, or about 22*s*. at the power-station. The power can be transmitted to Reykjavik, with an overall loss of 15 per cent., and the cost of power in the town will therefore be about £2 per h.p. year of 8,760 kw.-hours. The power available in Reykjavik will be 590,000 h.p. during the five winter months, and 940,000 during the remainder of the year.

There is an excellent ice-free harbour and every facility for the establishment of great electro-chemical factories, but as the island has only 90,000 inhabitants it will be necessary to import labour.

Large deposits of iron ore exist, but the quality of the ore so far analysed has been poor. Sulphur is found in enormous quantities. There are deposits of good lignite near Reykjavik. The voyage from Scotland occupies 48 hours by modern steamers. The distance to Halifax and to Gibraltar is about the same, and the town is therefore fairly central between Europe and America, and well suited for international trade.

GENERAL NOTES.

National Committee for Relief in Belgium.—The National Committee for Relief in Belgium announces that it has concluded its efforts and that no further contributions or gifts of clothing are required. The Committee was founded April 27th, 1915, and up to May 31st, 1917, collected solely from the British Empire £2,411,222 18*s*. 2*d*., or an average of £100,000 per month, which was expended through Mr. Hoover's organisation. On that date the announcement was made that in view of the American loan to Belgium the National Committee temporarily suspended its efforts. £18,372 19*s*. 11*d*. has since been received as a result of the original appeal. However, in October, 1918, to meet the urgent distress which immediately followed in the wake of the retreating Germans, the National Committee issued an appeal, which up to date has resulted in gifts of clothing to the value of £57,000. In addition, it received cash subscriptions from Great Britain and the Overseas Dominions to the amount of £74,280 1*s*. 11*d*., thus bringing the National Committee into the third place in the list of British War Charities, with total receipts from donations of cash and clothing amounting to £2,560,876.

Flax-growing by ex-Service Men.—In the House of Commons the Minister of Labour, Sir Robert Horne, was asked whether steps were being taken by his Department to facilitate the scheme for forming a colony of ex-Service men desirous of developing the flax-growing industry in British East Africa, and whether he was aware that land for the purpose of that colony had already been earmarked by the Governor of East Africa, and that a number of ex-Service men were anxiously awaiting the decision of the outstanding points in connection with the colony by the Ministry of Labour. Sir R. Horne replied that as regards the first part of this question, the scheme was under consideration. It involved the grant of a considerable sum of money by the State, and expert advice was being obtained on the possibilities of success. The answer to the second part of the question was in the affirmative. Replying to a further question on the subject, Sir R. Horne said the scheme referred to involved an expenditure which the Labour Ministry was not prepared in the circumstances to recommend. He added: "If the prospects are as good as claimed by the proposer of this scheme it should be possible to obtain financial support from other than Government sources; and I am informed that if a scheme of this kind making special arrangements for placing disabled officers and men were submitted to the Colonial Office, they would be willing, if satisfied with the nature and terms of the scheme, to urge the Governor of the Protectorate to grant land near a railway on preferential terms."

Coal in the United Kingdom, 1918.—The output of coal, which had fallen from 287,411,869 tons in 1913 to 248,473,119 tons in 1917, fell still further in 1918 to 227,714,579 tons, a decrease of 20,758,540 tons as compared with 1917, and of 59,697,290 tons as compared with 1913. The number of persons employed at mines under the Coal Mines Act was 1,008,867—a decrease of 119,023 on the pre-war year of 1913, and of 12,473 on the figures for 1917. The average output per person employed underground fell from 325 tons in 1913 to 294 tons in 1918.

Indo-Burma Aerial Mail Service.—The Government of Burma recently invited the Burma Chamber of Commerce to express its views respecting the conditions under which an aerial mail service should be maintained between Burma and India. The Chamber has replied that in its opinion a service every other day between Burma and India would probably meet the present requirements, but that in order to avoid delay a subsidiary aeroplane service should be established between Rangoon and Maymyo or such other towns as Government may consider necessary.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—June 20, 1919.

No. 3475. JUNE 27, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Telegrams: "Vacuum, Trowbridge." *Telephone:* 113 Trowbridge.

BURNETT MOTOR TYRES

Sole Proprietor:

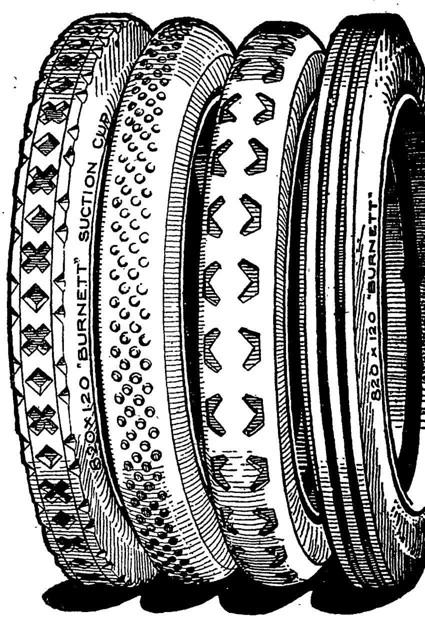
CUTHBERT BURNETT.

Shetland,
6th May, 1918.

Gentlemen,—

I would thank you to send me your list of tyres, etc. I may say I had one of your tyres some time ago, which gave me every satisfaction.

W. B.



Suction-Cup. Studded. Dauntless. Ribbed.
Patent 14519/10. Reg. No. 642307.

London, N.,
21st June, 1918.

Dear Sirs,—

We return you a tyre, No. 49404, 875 × 105, which may possibly be of interest to you. It has run on the off-side front wheel of a 33-cwt. lorry 7,808 miles without being taken off the rim: it was then punctured; afterwards it ran 1,519 miles, making a total of 9,327 miles. This mileage is considerably more than double the mileage of any other tyre we have had as yet.

POWELL & CO.

COMPLETE PRICE LIST ON APPLICATION TO

The BURNETT Motor Tyre & Rubber Co.

Yerbury Mills, Trowbridge, Wilts.

London Depot - - 71, MORTIMER ST., GREAT PORTLAND ST., W. 1.

CONTRACTORS TO THE BRITISH AND FRENCH WAR OFFICES, Etc.

All communications respecting Advertisements should be addressed to the
ADVERTISEMENT MANAGER, 97, GRESHAM STREET, E.C. 2.

Journal of the Royal Society of Arts.

No. 3,475. VOL. LXVII.

FRIDAY, JUNE 27, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The One Hundred and Sixty-fifth Annual General Meeting for receiving the Report of the Council, and the Treasurers' Statement of Receipts and Payments during the past year, and also for the Election of Officers and New Fellows, was held in accordance with the By-laws on Wednesday last, June 25th, at 4 p.m., Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

The Secretary read the notice convening the meeting, and the Minutes of the last Annual Meeting.

The following candidates were proposed, balloted for, and duly elected Fellows of the Society:—

Abrahams, William Henry, Calcutta, India.
Bailey, Captain William Charles, London.
Bate, Stephen Conrad Clavell, Langwith, near Mansfield.
Bedford, Lieut.-Colonel Sir Charles Henry, LL.D., D.Sc., M.D., Woking, Surrey.
Beresford-Jones, Captain Harry, M.B.E., J.P., Chester.
Cameron, H. Gordon, Ponders End, Middlesex.
Dickson, James, Sheffield.
Dollond, William George Balicourt, London.
Dupré, Fritz, London.
Ellis, Owen William, M.Sc., Assoc.M.Inst.C.E., London.
Farmer, Professor John Bretland, M.A., D.Sc., F.R.S., London.
Flanagan, William Henry, Buxton, Derbyshire.
Girod, Paul, Ugine, Savoie, France.
Hanby, Wilfred, Rotherham.
Harvey, Charles William, Portsmouth.
Hatton, William Henry, Leamington.
Heath, Frederick, Tacoma, Washington, U.S.A.
Holland, Sir Thomas Henry, K.C.S.I., K.C.I.E., D.Sc., F.R.S., London.
Hurst, James Edgar, Manchester.
Hutchison, Miller Reese, Ph.D., Orange, N.J., U.S.A.
James, John George William, London.
Jensen, Jens Möller, Copenhagen, Denmark.
Langwell, Captain Ernest Harry Allen, York.
Lax, Frederick, Hunslet, Leeds.
Lennox, John, Motherwell.
Lorkin, Walter Leonard, London.
Markham, Charles Paxton, Chesterfield.
Mitchell, Blayney, London.
Monahan, James Henry, Tripoli, N. Africa.
Nair, Theketh Kumaran, B.A., B.Sc., F.C.S., Jamalpur, India.
Nair, Dr. T. M., Burma.
Oates, David William, M.A., Newport, Monmouth.
Pascall, Sydney W., London.
Peile, Henry, Newcastle-on-Tyne.
Price, Major Joseph Benjamin, M.A., D.Litt., Sleaford.
Robinson, Captain Ernest Herbert, Pirbright, Surrey.
Robson, James, Handsworth, Birmingham.
Roper, John, M.I.Mech.E., London.
Rutherford, Walter, London.
Shurtleff, George F., New York City, U.S.A.
Sifton, Winfield B., London.
Sissons, Thomas Hall, J.P., Hull.
Stevens, Charles Howard, China.
Still, William Joseph, London.
Storey, Charles Blades Coverdale, M.A., Glyn, Denbighshire.
Styring, J. B., Sheffield.
Sullivan, Rev. Daniel Richard, Greensburg, Pa., U.S.A.
Tucker, Thomas, F.C.S., West Ham.
Upton, Alfred Ernest, Sheffield.
Webb, Duncan, Ancoats, Manchester.
Webster, John Herbert, A.M.I.Mech.E., Alloa, N.B.
Williams, Albert Edward, "A" Special Company, Royal Engineers, B.T. in France.

Williams, Lieut.-Colonel Arthur Cecil, R.A., C.B.E., London.

Wood, William Francis John, C.B.E., B.Sc., F.I.C., Barnsley.

Wright, George Henry, F.C.I.S., Birmingham.

The Chairman appointed Mr. Byron Brenan, C.M.G., and Mr. Julius Garratt scrutineers, and declared the ballot open.

The Secretary then read the following—

REPORT OF COUNCIL.

With the close of the Society's 165th Session, the Council are glad to be able to congratulate the Fellows on a successful year's work. The general standard of the papers read, both at the Ordinary Meetings and at the meetings of the Indian and Colonial Sections, has been high, and the papers have been followed by much valuable discussion. The number of Fellows elected since last June is 455, an increase of 82 over last year's total, and of 291 over the figure for 1916–17. In the entries for the Examinations, the increase which began in 1917 has been continued, the numbers being 34,173 for this year, as compared with 31,135 in 1918, and 26,185 in 1917. There would probably have been a still further increase this year, but for the demobilisation of the troops, which threw into confusion the arrangements made by the War Office for the education of men on active service.

I.—Ordinary Meetings.

In 1917 the Chairman (Mr. Alan A. Campbell Swinton) chose as the subject of the inaugural address "Science and its Functions," in which he showed, by a rapid sketch of its origin and progress in the past, and by some considerations of its scope and effects in the present, how largely dependent mankind is upon science for our modern civilisation. His address at the opening of the present session was a sequel to this, and dealt with "Science and the Future." After insisting on the importance of giving its proper place to science in our educational systems, and of affording opportunities for the private reading of technical books and periodic scientific literature by means of libraries, the Chairman referred to some of the developments which may be looked for in the future, including the universal dissemination of news by wireless telegraphy and telephony, and the distribution of electrical power on a great scale. He concluded with some reference to the potentialities of water and the sun as sources of power, and the suggestion that in photo-electric chemistry we have perhaps the most important problem that science of the future has to solve.

The subject of Liquor Control was dealt with by Lord D'Abernon, who produced some remarkable figures to show the effects of the policy of the Liquor Control Board over which he presides. In the course of the paper he discussed the question how far drunkenness is due to environment, and how far it is temperamental. During the period 1913–17 there was a remarkable decrease in drunkenness, the convictions of women for this offence falling from 35,765 to 12,307. It would, however, be hardly possible to deduce from this the prevalent cause of drunkenness. If alcohol is almost unattainable, people must remain sober, whether their temptation to drink is due to environment or to heredity.

Two papers were read on different aspects of the housing question. Mr. Seebohm Rowntree, who is generally recognised as a high authority on the statistical aspect of the problem, stated that if 325,000 new houses were built by the end of 1919, we should just make good the additional shortage of houses caused by the war. The figure is large, but good grounds were given for it, and it shows the magnitude and importance of the question which the Government have to solve. In addition to the positive shortage, a large proportion of existing houses in rural districts are unfit for human habitation. In view of these facts, Mr. Rowntree pleaded for a bold and extensive housing programme, and for a reasonable standard of accommodation and amenity. At the conclusion of the paper he touched on a point which bids fair to give trouble in the near future. The present high cost of building materials and labour will necessitate the expenditure of more capital on a house than was the case before the war. How are the rents to be approximately equalised? Mr. Rowntree threw out the suggestion that rates might be differentiated.

The second paper was read by Mr. Leonard Hill, who has already contributed two valuable papers to the Society's proceedings. This year he gave a third, "Infant Mortality and Housing," in which he dealt with a question that has come to be closely associated with his name—the importance of moving air to secure healthy surroundings. In the present conditions of town life the mortality of the infant population reaches very high rates, which are largely due to absence of air and sunlight, stuffy rooms, overloading with clothes, and coddling generally

He urged the necessity of building garden cities, where children may obtain plenty of air and exercise; and he made many suggestions as to the rearing of infants which, if carried out, would go far to secure a healthy and virile race.

One of the most striking features of the war is the great advance that medical science has made in combating disease. In previous wars from ten to fifteen men have died of disease to one who has died directly at the hands of the enemy; in the present war one man has died of disease to every ten whose death was caused in the field. The success of medical science with the fighting man has been shared by veterinary science in saving the lives of his faithful servants, the horses, dogs, camels, and oxen, which have patiently borne their share of the horrors of war. The steps by which this success was won were fully described by Major-General Sir Frederick Smith in a paper entitled "The Work of the British Army Veterinary Corps at the Fronts." He sketched the history of the Corps, which grew from small beginnings till it numbered 1,300 officers and 27,000 men, and he gave an interesting account of the way in which they treated over a million and a quarter four-footed patients.

An interesting historical account of the hand-knotted carpet trade in this country was given by Mr. A. F. Kendrick. In the course of this he bore testimony to the usefulness of the system of awarding premiums which was adopted by the Society in its earliest days. In 1756 a premium was offered for making carpets in England, in imitation of those made in Turkey and Persia. Several rewards were bestowed, which no doubt did a great deal to encourage a new industry; indeed, one factory is still prospering to-day which traces its origin to a recipient of the Society's awards.

Meteorology is one among many sciences the importance of which was suddenly emphasised by the war. Reliable weather forecasts were essential, alike for our air, sea, and land forces; but the problem of providing them was at first a very formidable one. In 1914 there were few trained meteorologists in the country. The outbreak of war, of course, reduced their sources of information by cutting off telegraphic reports from Central Europe, and wireless messages from ships; and with these handicaps the meteorological services were suddenly called upon to produce an enormously increased supply of weather reports. How it was done, how men were rapidly trained for the work, and how the various forces were kept supplied with the latest information, was described by Colonel H. G. Lyons, who, in conclusion, suggested some of the lines of research to which meteorologists will have to devote their attention in the near future.

When cotton seeds of the woolly varieties have been ginned, a considerable proportion of short fibres has hitherto remained on the hulls and has been practically wasted. By the invention of an ingenious machine, Mr. E. C. de Segundo has contrived to remove these fibres which, it is found, make excellent paper, artificial silk, etc. The machine was shown at work at the meeting when Mr. de Segundo read his paper. The new process is of importance, because it bids fair to give a very considerable value to a by-product of cotton, and this will probably encourage the cultivation of cotton in regions where, at present, it is only on the margin of profit.

The work of the Department of Scientific and Industrial Research was described by its secretary, Sir Frank Heath. He divided the field of work into three heads: (1) The encouragement of research workers; (2) the organisation of research by industries; and (3) the organisation of national research. For the first purpose the Department in the year 1916–17 spent over £3,500, and during the current year it has spent £10,000. Under the second head the Department has done useful work in inducing firms in various industries to combine. At the date when the paper was read (February, 1919) four Research Associations were at work; fifteen more were just coming into existence, and a further eleven were in the earlier stages of formation. Under the third head the Department is offering to assist other Government departments who desire to have researches undertaken on a scale and for purposes which they cannot themselves compass; and it is also organising research into practical problems which are of such wide importance that they cannot be handled by any one section of the nation.

In a lucid paper, Mr. W. L. Hichens discussed the wage problem in industry, which he describes as "the greatest problem that has to be faced in this country to-day." He dealt with the various schemes that have been proposed to abolish or modify the wage system, such as syndicalism, guild socialism, profit-sharing, and co-partnership, and as the result of his criticism came to the conclusion that there is no satisfactory alternative to the wage system. It is, however, liable to abuses, and Mr. Hichens proceeded to discuss how these abuses might be minimised. The conclusion

he came to was that the community, through its chosen representatives, should exercise its right to regulate the demands of both capital and labour; and while the organisations of employers and employed in each industry should be responsible in the first instance for negotiating all wage problems, the Government should review all decisions from the wider standpoint of the general interest, and regulate both the profits of capital and the wages of labour in order that a due proportion might be observed.

Mr. B. D. Porritt, in his fully documented paper, gave an account of the Rubber Industry, past and present. The first portion consisted of a history of the industry from its earliest times. This was compiled with minute care from original sources, a great deal of technical information being obtained from the reports of various law cases, especially those brought by Messrs. Hancock and Macintosh. In the second portion, Mr. Porritt referred to the present state of the industry, which he described as very satisfactory. Incidentally, he referred to the question of synthetic rubber; but, although he favoured the idea of encouraging research in this direction, it did not seem probable at present that synthetic rubber could be produced in sufficiently large quantities, or at sufficiently cheap prices, to take the place of plantation rubber.

The shortage of materials for oxy-acetylene welding during the war led to investigations into the possibilities of electric welding, both in this country and in America, with the result that great developments have been made in the process, especially in the last two years. Mr. W. L. Lorkin gave a full account of these developments, and a practical demonstration enabled the audience to gain some idea of the operation of the process. The method appears to be somewhat rough, as compared with oxy-acetylene welding, but it is very rapid, and for certain classes of work it seems to possess decided advantages. Much interest was expressed in the specimens of protective gear worn by the operators when using the electric arc; this now seems to have reached a satisfactory standard, and for the improvements in this respect much credit is due to Mr. Lorkin.

In view of the amount of public discussion which has been aroused by the proposal to establish super power-stations for the generation of electricity, special interest was taken by gas and electrical engineers in Sir Dugald Clerk's paper on "The Distribution of Heat, Light, and Motive Power by Gas and Electricity," and in Mr. J. S. Highfield's paper on "The Supply of Electricity." Sir Dugald dealt with the subject from the point of view of thermal efficiency. A masterly analysis of the figures showed that for the purposes of heating and power, gas involves very much less waste of coal than electricity, while in the matter of lighting there is perhaps little to choose between the two. Of course, before deciding on the general question of the relative advantages of gas and electricity in any particular undertaking, there are numerous other points—such as practical convenience, cleanliness, etc.—to be considered, in addition to thermal efficiency, and the paper made it clear that, while for certain purposes gas is the more economical agent, in other cases it is advisable to use electricity.

Mr. Highfield also discussed the much-talked-of problem of super-stations. While there is no question that stations of the largest possible size should be used in situations where a sufficient load can be collected within a moderate distance, and where there is an ample supply of water necessary for the running of a large turbine plant, a great deal of nonsense has been talked about the prospects of securing "cheap electricity" by means of super-stations. With the present high costs of plant, fuel, and labour, any serious reductions in price can hardly be looked for. Mr. Highfield traced the development of the electrical industry in this country from its beginnings, and he showed that whatever defects our various systems may possess are due rather to our politicians than to our engineers.

The necessity for conserving the coal supplies of the world has, during recent years, drawn serious attention to the question of utilising water-power. It is estimated that within the British Empire the amount of water-power available is of the order of fifty to seventy million horse-power. Of this, only some 5 per cent. is developed, and of this 5 per cent. 70 per cent. is in Canada; so that, when Canada is excluded, only about 2 per cent. of the potential water-power of the rest of the Empire is developed. If, as seems likely, it becomes feasible in the near future to harness this power on any considerable scale, there will be a great demand for hydro-electric engineers. Whence is the supply to come? Professor Gibson, in a short but suggestive paper, strongly urged the necessity for providing suitable training in hydro-electric engineering, and discussed the

various ways in which facilities for such training could best be supplied.

Linen is one among many articles for which an extraordinary demand was suddenly created by the war. It was required in vast quantities for aeroplane wings, tents, covers of all kinds for transports, wagons, ammunition, stores, ships' canvas, canvas for hangars, and numerous other purposes; and the greatest demand came at a time when the supplies from Russia, hitherto the chief source of our flax, were cut off. Mr. W. Norman Boase described the steps taken by the authorities to meet the situation. The Flax Control Board was started in 1917, having sub-committees in Belfast and Dundee, with the result that a great stimulus was given to the cultivation of flax, especially in Ireland, Scotland and Canada. In the course of his paper, Mr. Boase gave a brief history of linen from the earliest times, and this was followed by an account of the most modern methods of the cultivation, preparation, spinning, and weaving of flax.

Various questions in connection with railway transport in the United Kingdom were discussed by Mr. H. Kelway Bamber in a paper which bristled with statistics. Having first reviewed briefly the working results of all the railways of great Britain and Ireland during the decade preceding the outbreak of war, he estimated the prospective traffic of the near future, and considered how the requirements of this traffic might best be met. To this end he advocated, among other remedies, the gradual replacement of our existing 10-ton wagons by 45-ton wagons and self-discharging coal-wagons, such as are employed on the South African railways. He also referred, in conclusion, to the effect on British railways of through communication with the Continent, following upon the construction of the proposed Channel Tunnel, and showed that if a through service of trains is to be established, it will be necessary to construct a new line of railway from London to the Channel, or, at all events, to make considerable modifications in the existing systems in order to accommodate the larger continental wagons.

Sir Francis Piggott in his paper traced the evolution of the principles of Japanese design. The simplest form is the religious symbol, *pakwa*, or "divining rods," an arrangement of lines, either three long ones, or two long and two short. These may be arranged in various ways, which, as they became more elaborate, gradually developed into "key" patterns, diapers, and lattice work. From this he proceeded to discuss the Japanese methods of treating cloud and wave forms, and bird, flower and tree designs, and he claimed that "by their use of blank spaces, and a mysterious sense of proportion of ornament to space, the Japanese have found the secret of the hold which the best design has on the mind."

A new form of prime mover, invented by Mr. W. J. Still, which represents a combination of internal-combustion engine and steam engine, was described by Captain Frank E. D. Acland. In the usual gas or oil engine much of the heat generated by the combustion of the fuel passes away with the exhaust gases and with the water used for cooling the cylinders, and is thus wasted. In the Still engine this waste heat is employed to generate steam, and the piston, after being driven in one direction by gas or oil, is driven on its return stroke by steam. It is claimed that this engine shows a fuel efficiency at least 20 per cent. higher than that realised in other types of prime mover.

The manufacture of glass, of which a good deal was heard during the war, was dealt with at two of the Ordinary Meetings. Sir Herbert Jackson, who was appointed to deliver the second "Trueman Wood" lecture—the first was given last year by Sir Dugald Clerk—took as his subject "Glass and some of its Problems." After a general description of various types of glasses—optical, laboratory and scientific—he discussed the nature of vitreous substances and problems connected with devitrification. Some of these are of vital interest to glass manufacturers—*e.g.* the question to what extent a glass tends to crystallise, and at what temperatures and under what conditions segregation of crystals tends to take place, is important in securing homogeneity of optical glass, and also the proper behaviour of glass intended for working in the blow-pipe flame. In the latter part of his lecture Sir Herbert dealt with coloured glass, and showed a number of experiments in which very beautiful colours were obtained by the use of gold, copper, and selenium.

Mr. Harry J. Powell, in his paper "Glass-making Before and During the War," spoke from the point of view of the practical manufacturer. He described the condition of the industry before the war, the disastrous effects upon it brought about by foreign competition, and the manner in which British manufacturers were constantly being driven from one expedient to another in order to keep their works open. When the war broke out they were faced with a most difficult task: they had suddenly to

divert their activities into entirely new channels, and that, too, at a time when their supplies of skilled labour were depleted, and it was almost impossible to erect new buildings or to modify existing works. It is now generally known that the glass manufacturers rose magnificently to the occasion; how they did it is described by Mr. Powell, who has included in his paper summaries supplied by the principal glass firms of their special war developments.

In a paper on "Food Production by Intensive Cultivation," Dr. Frederick Keeble gave particulars of the increase in the amount of food produced in this country during the war, and of the methods adopted to encourage this increase by the Food Production Department, of which he is Controller. Unfortunately, owing to extreme pressure of work in his Department, Dr. Keeble has not yet been able to complete the manuscript of his paper.

For a similar reason the publication of Dr. J. F. Crowley's paper on "The Use of Electricity in Agriculture" has been delayed.

II.—Indian Section.

The Jubilee session of the Indian Section began on November 28th with the delivery of a brilliant address by an eminent Bengalee, Mr. Bhupendranath Basu, member of the India Council, on "Some Aspects of Hindu Life in India," a life of which in the past we have not had much actual inside information. Twenty years or more ago a well-known European residing in Calcutta told us as much as can be known by those not of the Hindu faith; but, as Lord Crewe, the Chairman at the opening meeting of the Section, remarked, no Englishman, however sympathetic or well-informed, could have dealt with the subject as Mr. Basu, with his inner knowledge, was able to deal with it. That the ancient ways still endure in India after having disappeared from nearly all seats of past civilisation cannot, he submitted, be accounted for by merely saying "East is East." His explanation of the deeper causes formed not the least interesting feature of a paper so enlightening as to cause one to hope that he may be willing to instruct the Society on other important aspects of Hindu society that he was obliged to exclude for want of time.

Mr. Basu, in his concluding remarks, looked forward to a greater knowledge on our part of his country and its people. So far as Mr. Basu's own province is concerned, Mr. W. R. Gourlay thinks that this will be best achieved by the preparation of a great history of Bengal. In his paper urging the need of such a work, he observed: "From what I hear said by people who have had no opportunity of becoming acquainted with Bengalees at first hand, I think it is possible that in this country, and perhaps also in other countries, there is considerable misapprehension regarding the character of the Bengalees as a race." He holds that this highly intellectual, deeply emotional, and intensely religious people are likely to take a leading part in the development of India and the future of the British Empire. A readable book on the lines he sketched would afford everyone an opportunity of understanding how Bengalees have come to occupy their existing position and what are their aspirations, "and we might then, through a knowledge of the past, look into the future and thus find guidance for the present." The project was cordially supported by the ex-Governor of Bengal, Lord Carmichael, who presided, and by others connected with that Presidency. One speaker, Sir Charles S. Bayley, held that a specially qualified official of the rank of a "collector" should, as a permanent arrangement, be chosen to undertake the task indicated by Mr. Gourlay or any other similar work of benefit to India.

The Society is entitled to claim some credit for giving early and, it may be hoped, helpful attention to the recently-issued report of the Indian Industrial Commission. At the meeting in March the far-reaching proposals of that Commission were reviewed by the Indian Trade Commissioner, Mr. D. T. Chadwick, whose very able paper led to an exhaustive discussion in which leading East India merchants and others specially interested took part, and a resolution was adopted asking the Council to convey to the Secretary of State and the Government of India the desire of the representative audience that prompt action may be taken, including the appointment of a special officer with adequate staff, to give effect to the recommendations of the Commission.

Mr. Herbert Kelway-Bamber, in the excellent paper he read earlier in the session, pointed out that one of the results of the new industrial policy contemplated would be a much larger call on the resources of the Indian coalfields, the best of which are remote from ports and cities, and he suggested means by which the cost of fuel transport, already low, might be still further lowered. He estimated that by replacing existing rolling-stock with wagons of another type there are possibilities of reductions amounting to 61 per cent. in the number of vehicles to be

handled, 32 per cent. in the shortening of train length, and ·11 per cent. in the dead-weight hauled.

A valuable paper on "Soil Deficiencies in India, with Special Reference to Indigo" was read by Professor Henry E. Armstrong, F.R.S., on May 15th. Mr. A. W. Davis, Indigo Research Chemist to the Government and former pupil of Professor Armstrong, is convinced, from his study of many indigo estates, that the actual fertility practically always (except in certain specified cases) corresponds closely with the available phosphate contents of the soil. Other experts consider that defective aëration or water-logging are the causes of failure. In view of the importance of the issues involved, Professor Armstrong dealt at length with the different views expressed. To some extent, the paper must be regarded as complementary to the author's course of Cantor Lectures on "Problems of Food." With reference to the general question of natural *versus* synthetic indigo, the views the Professor expressed were in a certain degree such as to encourage the Indian planter to persevere in spite of the serious obstacles. Professor Armstrong's assistance to the India Office in its praiseworthy efforts to procure the standardisation of the natural product, and so, if possible, make things better for the growers, was referred to by Sir William Duke, Chairman on the occasion, and by Sir Claude Hill, Member of the Governor-General's Council.

A supremely interesting paper on "Aviation as Affecting India" was read at the final meeting of the session, on June 5th, by Brigadier-General Lord Montagu of Beaulieu, the Adviser on Mechanical Transport Services to the Government of India. He described India as an ideal country for aerial transit, and urged that by reason of its pre-eminence, commercially, among the Dominions of the Crown, and on other grounds, she is entitled to all the advantages derivable from the use of aircraft, especially for internal postal services and passenger traffic. He mentioned that from September to June on nine days out of ten the weather is perfect for flying, while as to the south-west monsoon recent investigations show that the prevalent air-current in the rainy season is comparatively shallow, and that above the clouds there is generally a clear sky. The prediction Lord Montagu made five years ago that the first long-distance route accomplished would be the one from England to India that he outlined has been fulfilled. He now prophesies that within a few months regular services for mail matter, *i.e.* "airgrams," etc., will be established, but says it will be a long time before passengers can be profitably carried, and then, he inclines to think, dirigibles "without any intermediate stop" will be preferred. By the courtesy of the Air Department a number of remarkable official photographs were exhibited, reproducing incidents of the first flight to India, a flight about double the width of the Atlantic. The Minister in charge of the Royal Air Force, Major-General J. E. B. Seely, M.P., was in the chair, and in the course of an important speech he announced that arrangements are now being made for a mail route between Egypt and India.

III.—Colonial Section.

At the opening meeting of the Colonial Section on November 21st, an important paper on a subject of high and immediate interest, the Pacific, was read by perhaps the greatest authority on that region, the ex-Governor of Fiji and High Commissioner for the Western Pacific, Sir Everard im Thurn. "It seemed to me," he said, in his introductory remarks, "that at the present great moment in the history of the world a statement by an eye-witness and student of the 'present state of the Pacific Islands,' and of how they came into that state, might be useful." On the question of the rearrangement of the islands, since determined by the Peace Conference, he held, as he has always held, that eventually "the whole of what are, and may become, British possessions must pass into one Australasian Federation." In view of the Paris settlement, it may be recalled that Sir Everard intimated that if the matter were left to him he would apportion to Japan certain small islands away to the north.

Many attempts have been made to explain the precise meaning of the term "key industries," and to assign their exact position in the economic structure of the nation and of the Empire. The object of the paper which Mr. Edward J. Duveen read on February 25th was to "enable a wider public to envisage the true character of 'key' or 'pivotal' industries and to understand their relation to national well-being." The industries specially dealt with by Mr. Duveen were glass, metals and minerals, magnetos, and thoria and ceria. He emphasised the importance of essential key industries being obtained for the nation—we should, he contended, encourage foreigners to bring their inventions to us—and

of the State ensuring the establishment of the new industries on a firm foundation.

The admirable papers, "Science and Industry in Canada," read on March 4th by Professor John Cunningham McLennan, and "Science and Industry in Australia," read on May 27th by Lieut.-Colonel the Hon. Sir John McCall, contain a mass of most useful information, and afford evidence of the wonderfully energetic way in which the Oversea dominions are developing their abundant natural resources. In the case of Canada, the war, Professor McLennan pointed out, has given an immense impetus to industrial development, a development "far away and beyond all expectations which were held regarding the capabilities of Canada by the most sanguine and the best informed of her leaders." Similarly, Sir John McCall mentioned that some of the industries to which he referred have been encouraged and others forced upon the Commonwealth by the same cause. Both Professor McLennan and Sir John McCall directed attention to the smallness of the respective populations of Canada and Australia compared with the enormous extent of the countries. Canada, covering half the North American continent, has still only eight million inhabitants; Australia, with an area of three million square miles, not more than five millions. These two remarkable papers recall and enforce the famous saying of his Majesty on the completion of his tour of the Empire, "Wake up, England!" and might well be carefully studied by "captains of industry" in the Motherland.

IV.—Cantor Lectures.

The first course of Cantor Lectures, delivered by Professor James C. Philip, dealt with Physical Chemistry and its bearing on the chemical and allied industries. The somewhat difficult theory of this comparatively new branch of science was very clearly expounded, and particular attention was paid to the *rôle* of the catalyst from the standpoint of physical chemistry, and the part played by it in industry, especially in such cases as the hardening of fats, etc. The physical chemistry of the absorption of gases and dissolved substances, with practical questions such as the storage of acetylene, the production of high vacua, the absorption of poison gases by gas-masks, various dyeing processes, and adsorption in soils, was fully discussed; and a confident opinion was expressed that the extended application of the quantitative methods of physical chemistry in connection with technical processes, is bound to make for efficient working and rational control.

The scientific problems of electric wave telegraphy were the subject of the second course, which was given by Professor J. A. Fleming. He described the various theories of electromagnetic waves, and gave an account of the methods of creating damped and undamped waves for radiotelegraphy. The problem of transmitting long electro-magnetic waves over sea and land, involving questions connected with the diffraction of such waves round the earth, and the effect of the atmosphere on the waves, was ably dealt with. In the last lecture of the course, Professor Fleming discussed the detection of electro-magnetic waves, and he concluded with a very interesting description of the development of the thermionic detector, the Fleming valve, and the three-electrode valve in radiotelegraphy and raidotelephony.

In the third course, under the title "Problems of Food and their Connection with our Economic Policy," Professor Henry E. Armstrong discussed the present state of our knowledge of foodstuffs —their character, functions and assimilation. He laid great stress on the importance of securing fresh foods, both animal and vegetable, and showed how the various preserving processes tend to destroy the vitamines and other elements essential to our physical well-being.

V.—Juvenile Lectures.

A course of two Juvenile Lectures was given during the Christmas recess by Mr. Charles R. Darling, who chose for his subject "Liquid Drops and Globules." With the aid of a large number of pretty experiments, he illustrated the behaviour of drops of liquids under various conditions, the effect of temperature on the density of liquids, "diving drops," the making of stable columns of liquids, and an extremely simple form of spinning top which owes its rotation to surface tension. The formation of mists, fogs, and rain was also explained and demonstrated, and a series of striking experiments was shown, to illustrate the action of globules floating on liquid surfaces.

VI.—Scheme for the Promotion of Industrial Art.

Towards the close of 1917 the Council decided that, in order to carry out the object of their charter, "the encouragement of Arts, Manufactures, and Commerce," they could not do better than resume their efforts to promote the union of Industry and Art in this country, with

the object of improving the artistic and workmanlike qualities of British manufactures, and maintaining for British trade its proper position in the markets of the world.

Accordingly they appointed an Industrial Art Committee which included, in addition to persons nominated by the Royal Society of Arts, representatives of the Arts and Crafts Exhibition Society, the Design and Industries Association, and the London County Council Consultative Committees on Silversmithing and Allied Trades, Book Production, and Furnishing and Allied Trades.

This committee, after making very careful inquiries among manufacturers, distributors, educational authorities and others, drafted a scheme for the Promotion of Industrial Art, and arrangements were made to hold a meeting on October 28th last, at which the chair was taken by the Right Hon. H. A. L. Fisher, M.P., President of the Board of Education, when the scheme was to be submitted to the public.

Meantime a scheme for the establishment of a British Institute of Industrial Art was being promoted under the joint auspices of the Board of Trade and the Board of Education, "with the object of raising and maintaining the standard of design and workmanship of works of industrial art produced by British craftsmen and manufacturers, and of stimulating the demand for works of real excellence." The principal feature of this scheme was to be a permanent Exhibition in London of modern British works, selected as reaching a high standard of artistic craftsmanship and manufacture.

The Industrial Art Committee held several conferences with the authorities of the Board of Trade and the Board of Education, and, as the two schemes were considered to be mutually complementary, it was intended that they should work in the closest co-operation.

Shortly before October 28th, the authorities of the British Institute of Industrial Art suggested that at the proposed meeting a joint appeal should be made on behalf of the two schemes, and this accordingly was arranged. The meeting was held, and it was attended by a large audience, who approved the scheme and endorsed the proposal to issue the joint appeal.

In accordance with the scheme, an executive committee was appointed by the Council in January, 1919. This committee came to the conclusion that the Society's scheme as submitted to the meeting on October 28th was too indefinite and general in its objects to attract public support, and they thought it advisable, before issuing an appeal, to see if it was possible to introduce more definite and concrete proposals. Accordingly they appointed a sub-committee, which is now making inquiries as to the facilities for artistic and technical education afforded in connection with various industries, with a view to suggesting means by which such facilities may be developed and improved.

One of the objects of the scheme was to encourage propaganda work, especially by means of papers and lectures; and it is hoped that, as one result of the Society's deliberations in this direction, the programme for next session may include a number of papers and lectures on subjects dealing with Industrial Art.

VII.—Albert Medal.

The Albert Medal of the Society for 1919 has been awarded by the Council, with the approval of the President, H.R.H. the Duke of Connaught and Strathearn, K.G., to Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S., in recognition of his work as the pioneer of wireless telegraphy.

Sir Oliver Lodge's earliest researches in electro-magnetic radiation may be traced back to a period just thirty years ago when, in his lectures on "The Protection of Buildings from Lightning," delivered before the Society, he referred to his investigation of the oscillatory character of electrical discharges along conductors. To this "electrical oscillation—a surging of the charge of the wire," he attributed many of the accidents, previously incomprehensible, caused by discharges between lightning conductors and other conductors, such as metal gutters, gas-pipes, etc., unconnected with the lightning conductor. It may probably be assumed that the continuation of these researches would have led Lodge to similar results to those predicted by Clerk-Maxwell and obtained by Hertz, the latter of whom anticipated Lodge by observing electric waves in air, or rather in space, and is therefore justly entitled to the credit of the discovery of electro-magnetic radiation, the discovery on which all the later developments of wireless telegraphy are based.

Lodge, however, continued his investigations after the publication of Hertz's observations in 1887 and 1888, and while he did much to assist the recognition of the value of Hertz's work, he also contributed largely, by his own independent researches, to the completion of Hertz's discoveries, and ultimately to their

practical application, after the latter's early death in 1894. Sir Oliver Lodge discovered a more efficient means of detecting electric oscillations than Hertz's "spark gap" in his "coherer," the best form of which, the well-known "tube-filings" instrument, was independently devised by Branly. In 1894, at the Royal Institution, and at the Oxford meeting of the British Association in the same year, Lodge exhibited a complete set of apparatus for the production of Hertzian waves (the transmitter) and their detection (the receiver). By the use of this apparatus he was able to transmit signals without the use of a connecting wire, and he is therefore entitled to the credit of being the first person to send such signals by Hertzian waves between two separate and unconnected stations. The distance of transmission was limited; at the Royal Institution the signals were sent merely from one room to another, at Oxford over a greater distance; but the idea of applying the new system to telegraphic purposes was obvious, and, indeed, was immediately taken up by more than one person.

The general principle of "syntonic" telegraphy, that transmitter and receiver should be so "tuned" as to be mutually responsive and capable of sending and receiving waves of a certain length only, had been, Sir Oliver Lodge tells us in one of his published statements, in his mind since 1890, but the working out of the practical details took some time, and it was not till 1897 that he took out a patent covering his methods of tuned radiotelegraphy. The validity of the patent has been tested by the only means existing for the testing of such claims—trial in a court of law—and the judgment of Mr. Justice Parker in granting a prolongation of the patent in 1911 indubitably affirms the right of Sir Oliver Lodge's claim to be the inventor of syntonic wireless telegraphy. All modern radiotelegraphy is based on this syntonic principle.

No great invention has ever been the production of a single mind, and so it has been with wireless telegraphy. The starting-point may be taken to have been Clerk-Maxwell's mathematical investigations in 1864. Fitzgerald endeavoured, about 1883, to realise Maxwell's theoretical suggestions by the creation of electric waves. Later, Lodge detected and measured such waves in conductors. Hertz in 1887–88 detected and measured such waves in open space, having been anticipated in 1879 by Hughes, who, however, did not publish his results. Crookes, in 1892, foretold some of the possible practical results of Hertz's discoveries, while Lodge was the first to send actual signals by their means. Later, Lodge worked out and patented the syntonic method. Fleming, Admiral Jackson, Righi, Poulsen, and others have contributed to the scientific and practical development of the system, while Marconi, whose first patent was applied for in 1896, by assiduous labour and continuous experiment, made wireless telegraphy a commercial success.

As the fruitful labours of Senatore Marconi were fitly recognised by the award of the Albert Medal five years ago, so the Council of the Society consider it right and just that the claims of Sir Oliver Lodge as the leading pioneer in the inception of radiotelegraphy should be similarly acknowledged.

VIII.—Medals for Papers.

The Council decided to award six medals for the papers read before the Society during the present session—four for papers read at the Ordinary Meetings and one each for those read at the Indian and Colonial Sections.

The following awards have been made:—

At the Ordinary Meetings:—

Edward C. de Segundo, Assoc.M.Inst.C.E., M.I.Mech.E., M.I.E.E., "The Removal of the Residual Fibres from Cotton Seed, and their Value for Non-textile Purposes."

Sir Frank Heath, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

Walter Leonard Lorkin, A.M.I.E.E., "Electric Welding and its Applications."

W. Norman Boase, C.B.E., "Flax—Cultivation, Preparation, Spinning, Weaving."

In the Indian Section:—

Brigadier-General Lord Montagu of Beaulieu, C.S.I., "Aviation as affecting India."

In the Colonial Section:—

Professor John Cunningham McLennan, O.B.E., Ph.D., F.R.S., "Science and Industry in Canada."

For many years it has been the practice that no medals should be awarded to readers of papers who had previously received medals from the Society or were members of the Council. Acting on this rule the Council were precluded from considering the following papers:—

At the Ordinary Meetings:—

Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Distribution of Heat, Light and Motive Power by Gas and Electricity."

Leonard Hill, M.B., F.R.S., "Housing and Infant Mortality."

Sir Francis Taylor Piggott, M.A., LL.M., "The Principles of Design in Japanese Art."

Harry J. Powell, "Glass-making Before and During the War."

In the Colonial Section:—

Lieut.-Colonel the Hon. Sir John McCall, K.C.M.G., M.D., LL.D., Agent-General for Tasmania, "Science and Industry in Australia."

The Council, however, desire to express their high apppreciation of these papers.

IX.—Swiney Prize.

In accordance with the provisions of the will of Dr. George Swiney, the prize bearing his name was duly awarded in January last, on the seventy-fifth anniversary of the testator's death. Dr. Swiney died on January 20th, 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize, on every fifth anniversary of his death, to the author of the best published work on Jurisprudence. The prize was to be a cup of the value of £100, and money to the same amount; the award to be made jointly by the Royal Society of Arts and the Royal College of Physicians.

A meeting of the adjudicators of the prize was held on Tuesday, January 21st, 1919, under the presidency of Mr. Alan A. Campbell Swinton, F.R.S., the Chairman of the Council.

The adjudicators received a report from the joint Committee of the Royal Society of Arts and the Royal College of Physicians, recommending that the prize should be awarded to Dr. Charles Arthur Mercier, for his work "Crime and Criminals," and they adjudged the prize in accordance with the recommendation. Dr. Mercier had previously received the prize in 1909, for his work, "Criminal Responsibility," but, in view of the originality and merit of his new book, the adjudicators resolved to award to him the prize a second time.

X.—Owen Jones Prizes.

Following the precedent of the last two years, the Council offered the Owen Jones Prizes—which were formerly awarded on the results of the National Competition—direct to the Schools of Art, and appointed their own judges to make the awards. By the kind permission of the Director of the Victoria and Albert Museum, the necessary accommodation and facilities for judging the works were provided at the Museum.

The competition in 1918 was limited to Designs for :—(1) Chintzes, and other Stamped, Printed, or Stencilled Textile Materials; (2) Wallpapers; and (3) Tiles. Thirty-seven designs were sent in from nine Schools by thirty-one students. These numbers showed a considerable falling off as compared with those of the previous year, when 120 designs were submitted from twenty-two schools by seventy-three students. The judges attributed the decrease partly to more strenuous war conditions, and partly to the nature of the subjects prescribed, which were probably less attractive than the subject, "Textiles," set in 1917.

According to the report of the judges,* the general standard of the work was good, though somewhat uneven; and they were of opinion that greater care had been paid by the competitors than in former years to the technical requirements of the processes for which the designs were intended.

The work was exhibited to the public at the Museum, from July 20th to August 31st.

In order to secure that opportunities should be given to students at schools of art to compete, at some time during their courses, in the subjects in which they are specially interested, the Council have now divided up the subjects into three groups, in each of which prizes will be offered in every third year. Full particulars of the syllabus were given in the *Journal* of November 29th last (pp. 23 and 24). The designs for this year's competition have to be delivered at the Victoria and Albert Museum between June 23rd and 28th.

XI.—Examinations.

The examinations were held this year, as usual, in two divisions—the first from April 7th to 16th, and the second from May 26th to June 4th. The entries for the first division were 11,976, and those for the second 22,197, making a total of 34,173.

The highest number of entries ever reached was in 1914, when they totalled 37,974. In 1915, the first year of the war, they dropped to 32,113, and in 1916 there was a further fall to 25,968. In 1917, however, there was a slight recovery to 26,185; in 1918 the number rose further to 31,135, and this year the improvement is continued, the total being 34,173, an increase of 3,038 over the total for 1918.

The liberality of the Worshipful Company of Clothworkers has enabled the Council, as in past years, to offer the usual silver and bronze medals. These medals are very highly valued by the successful candidates, and there can be

* See *Journal*, Vol. LXVI. p. 565.

no doubt that they contribute not a little to maintain the high standard of the examinations.

The results of the Advanced and Intermediate Stages of the First Division of the Examinations, held in April, have already been communicated to the candidates; and those of the Elementary Stage of the April Division and all stages of the May Division will be announced as soon as possible.

The usual detailed report of the examinations will be printed in the *Journal* in the autumn.

XII.—Special Examinations for Troops on Active Service.

At the request of the War Office the Council arranged to hold special examinations in February last for troops on active service. These were to be conducted at centres close behind the various fronts, and also in training camps at home. At one time it appeared probable that the numbers of entries would be considerable, but, owing to the demobilisation of troops, these expectations were not realised, and the actual entries only amounted to 245, the subjects of examination being French (Stages III. and II.); Book-keeping (Stages II and I.); and Arithmetic (Stage I.).

XIII.—Viva Voce Examinations in Modern Languages.

Up to the present date fourteen examinations in French, German, and Spanish have been held this year in London, Coventry, and Manchester.

At these examinations 282 candidates presented themselves, of whom 214 passed (83 with distinction) and 68 failed.

Other examinations have been arranged in French, Italian, and Russian.

XIV.—Chadwick Trust.

Under the provisions of the will of Sir Edwin Chadwick, who died in 1890, the Royal Society of Arts nominates a member of the Trust established by Sir Edwin for certain purposes connected with sanitary education and the advancement of sanitary science. Each Trustee is appointed for a period of five years. The Trust was formed in 1896, and the Society's representatives on the Trust have been as follows:—

Sir Douglas Galton	1896–1899*
Mr. Brudenell Carter	1899–1904
Sir William Abney	1904–1909
Sir Henry Trueman Wood	1909–1914
Mr. John Slater	1914–

* Sir Douglas Galton died in 1899.

Mr. Slater's term of office expired this year, and he has been re-nominated the Society's representative for a further period of five years.

XV.—Conjoint Board of Scientific Societies.

The Board was established in 1916 by the Royal Society, and was then composed of representatives of twenty-six learned societies, of whom the Royal Society of Arts was one. Since that date twenty-eight other societies have been admitted, and the total number of constituent societies is now fifty-four. In addition to the Executive Committee, there are now fifteen committees which have been appointed for various purposes, and it is through these committees that most of the work of the Board is carried on.

The Education Committee has reported upon the scientific needs of the Civil Service, and criticised some of the recent proposals; the Iron Ore Committee has carried out a research on some anomalies revealed by magnetic surveys, and arrived at a satisfactory explanation of those investigated; the Water-power Committee has issued two valuable reports calling the attention of the Government to the existence of 50 to 70 million horse-power in the Empire, and urging that this should be investigated and safeguarded. The Aeroplane Timber Committee has gone into the trade nomenclature of timbers with a view to standardisation; the Adhesives Committee has made discoveries which would probably have prevented the threatened shortage of glues for aeroplanes, and is now pushing its inquiries into the question of quality rather than quantity. The Geophysical Committee is advocating the formation of a geodetic and geophysical institute.

The Board has also rendered services in the matter of the press censorship of scientific publications, and with regard to the supply of paper for the publication of the constituent societies.

The delegates appointed in the first instance to represent the Society were Sir Philip Magnus and Sir Henry Trueman Wood, who still continue in office.

A contribution of ten guineas has been made by the Council this year to the funds of the Board.

XVI.—New Council.

The Vice-Presidents retiring under the ordinary regulations are Lord Blyth, Major Percy

A. MacMahon, Viscount Northcliffe, and the Hon. Richard Clere Parsons. In their place the Council recommend Lord Askwith, Sir George T. Beilby, Mr. Thomas Jewell Bennett—all of whom have served on the Council in former years — and Sir Dugald Clerk, who has been an Ordinary Member of Council since 1915. Sir Henry Trueman Wood, who was appointed a Treasurer in 1918, has been nominated as a Vice-President by H.R.H. the President.

The four Ordinary Members of Council retiring are Sir Dugald Clerk, Dr. William Henry Maw, who is nominated as a Treasurer, Sir Francis Taylor Piggott, and Mr. James Swinburne. In their place the Council recommend Sir E. H. Tennyson d'Eyncourt, Mr. George Henry Drummond, Mr. John Somerville Highfield, and Sir Herbert Jackson, none of whom have yet served on the Council.

XVII.—Obituary.

The Society has lost several distinguished Fellows during the past year.

Sir William Crookes received the Society's Albert Medal in 1900, and he served on the Council from 1905 to 1909.

Sir Boverton Redwood served on the Council, with the necessary intervals required by the by-laws, from 1904 till his death on June 4th.

Colonel Theodore Roosevelt was elected a life member in 1910.

Sir Charles Wentworth Dilke was only elected a Fellow in 1917, but the name had been connected with the Society since 1845—his father, grandfather, and great-grandfather having all been members.

Sir John Jardine and Sir Frederick A. Robertson were both active members of the Indian Section Committee.

Among other notable Fellows of the Society who have died during the last twelve months, may be mentioned the Right Hon. Sir Henry Bargrave Deane, Judge William Denman Benson, Brigadier-General Alexander Beamish Hamilton, Mr. Alfred Hewlett (who was elected in 1863), and Sir Edward Montagu Nelson.

XVIII.—Finance.

In accordance with Section 40 of the Society's By-laws, the Financial Statement for the year 1918 was published in the *Journal* of June 20th. This shows that the adverse balance of £346 19*s*. 10*d*. which appeared in the Financial Statement for 1917, had been converted into a favourable balance of £796 4*s*. 10*d*. on the working of the year 1918. The result is mainly due to the fact that the Commissioners for Inland Revenue agreed to remit the income tax hitherto levied on the Society's funds, and they refunded the sum of £799 5*s*. 3*d*., the amount of income tax paid by the Society for the previous three years.

The amount received in annual subscriptions in 1918—viz., £4,745 13*s*—shows an increase of £639 15*s*. over the figure for 1917; while the amount received in life compositions—£1,034 18*s*.—is the largest ever received by the Society under this head in one year, and shows an increase of £473 13*s*. over the corresponding figure for 1917.

The income has risen from £9,952 14*s*. in 1917 to £12,635 9*s*. 7*d*. in 1918. On the other hand there has been a general increase in expenditure from £10,299 13*s*. 10*d*. in 1917 to £11,839 4*s*. 9*d*. in 1918. The greater part of the increase is due to the higher cost of the *Journal*, which again is due to the enormously increased costs of printing and paper. It is hoped that there will soon be a diminution in the cost of paper; but in the case of other items, such as salaries, wages, taxes and general expenses, little relief is to be looked for.

The Chairman (Mr. Alan A. Campbell Swinton, F.R.S.) moved the adoption of the report. The Society, he thought, was to be congratulated upon having, so to speak, taken a new lease of life. During the earlier stages of the war there was naturally a falling-off in the membership; later on difficulties caused by the enormously increased cost of printing and paper had to be faced, and at one time the prospects looked rather black. But now the Society seemed to have turned the corner, and the membership was again increasing. This session a record number of new Fellows had been elected, greater than in any previous year since the seventies. Of course, they must remember that the Society depended chiefly upon the subscriptions to carry on its work, and although it possessed invested funds the bulk of the revenue was derived from the subscriptions of Fellows. He hoped the Fellows would bear that fact in mind, and induce as many of their friends as possible to join the Society. The *Journal*, he considered, fulfilled a useful want. It disseminated a large and varied amount of scientific and commercial knowledge, and even those Fellows who were unable to attend the meetings and lectures derived full value for their subscriptions from the contents of the *Journal*. Various eminent people had time after time told him that they considered the *Journal* most valuable, as it contained information which they did not find in any other periodical. Although they were now able to make both

ends meet, and they hoped in course of time the cost of printing and paper would come down, yet he was afraid a great deal of their extra expenditure would be more or less permanent, and they could not hope for very much reduction. The report dealt with such a large number of matters that he could not refer to all of them; but he would like to say that the award of the Albert Medal to Sir Oliver Lodge had been a great personal gratification to himself, because he considered Sir Oliver had not received the recognition he deserved for the important work he did in the early days of wireless telegraphy. It was a subject he had followed very closely, and he was present when Sir Oliver Lodge gave his memorable lecture at the Royal Institution, and showed that signals could be sent from one place to another by Hertzian waves. Unless Sir Oliver Lodge, or somebody else, had done this pioneer work, he did not think we should ever have had practical wireless telegraphy. The medal had been awarded to Senator Marconi for having made wireless telegraphy a practical and commercial success, and the present award to Sir Oliver Lodge was for having carried out the necessary pioneer work. There was another matter, which did not appear in the report, and to which he would refer. It was thought well that some memorial should be established to the late Sir George Birdwood, who was a very old member of the Society, and one of its most active supporters. An appeal had therefore been issued, and it was now proposed to close the fund as sufficient money had been received to provide for an annual lecture, on a subject connected with India, which would be called the "Sir George Birdwood Memorial Lecture." This would keep Sir George's memory alive, which he was sure his many friends would all wish to do.

Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., said he had great pleasure in seconding the proposal that the report should be adopted. It was exceedingly well put together, and gave an excellent account of the year's work.

The adoption of the report was then agreed to.

The Chairman proposed a cordial vote of thanks to Mr. G. K. Menzies (the Secretary), Mr. S. Digby (the Secretary of the Indian and Colonial Sections), Mr. George Davenport (the Chief Clerk), Mr. J. H. Buchanan (the Accountant), and to the other officers of the Society for their services. The papers read during the past session, he considered, had been of a very high standard, and he would ask those present to accord to all the officers of the Society a hearty vote of thanks for their very successful work.

The Secretary (Mr. G. K. Menzies) returned thanks for this expression of confidence in himself and in the other officers of the Society.

The ballot having remained open for half an hour and the scrutineers having reported, the Chairman declared that the following had been elected to fill the several offices. [The names in *italics* are those of Fellows who have not, during the past year, filled the office to which they have been elected.]

President.

H.R.H. The Duke of Connaught and Strathearn, K.G.

Vice-Presidents.

Lord Askwith.

Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.

Sir George T. Beilby, LL.D., F.R.S.

Thomas Jewell Bennett, C.I.E., M.P.

Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.

Sir William Henry Davison, K.B.E., D.L., M.P.

Sir William Duke, G.C.I.E., K.C.S.I.

Sir Walter Egerton, K.C.M.G., LL.D.

Peter MacIntyre Evans, M.A.

Sir Robert Abbott Hadfield, Bt., D.Sc., D.Met., F.R.S.

Field-Marshal Sir Douglas Haig, K.T., G.C.B., O.M., G.C.V.O., K.C.I.E.

Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc.

Lord Islington, P.C., G.C.M.G., D.S.O.

Lord Leverhulme.

Sir Philip Magnus, Bt., M.P.

Major-General Sir Desmond D. T. O'Callaghan, R.A., K.C.V.O.

Major Francis Grant, Ogilvie, C.B., LL.D.

Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.

Lord Sanderson, G.C.B., K.C.M.G.

Alan A. Campbell Swinton, F.R.S.

Sir Aston Webb, K.C.V.O., C.B., P.R.A.

Sir Henry Trueman Wood, M.A.

Ordinary Members of Council.

Sir Charles Carrick Allom.

Edward Dent, M.A.

Sir E. H. Tennyson d'Eyncourt, K.C.B.

George Henry Drummond.

Martin Onslow Forster, D.Sc., F.R.S.

John Somerville Highfield, M.Inst.C.E., M.I.E.E.

Sir Herbert Jackson, K.B.E., F.R.S.

Major Edward Humphrey Manisty Leggett, R.E., D.S.O.

John Slater, F.R.I.B.A.

Professor John Millar Thomson, LL.D., F.R.S.

John Augustus Voelcker, M.A., Ph.D., F.I.C.

Sir Frank Warner, K.B.E.

TREASURERS.

William Henry Maw, LL.D., M.Inst.C.E.

Carmichael Thomas.

SECRETARY.

George Kenneth Menzies, M.A.

On the motion of the CHAIRMAN, a vote of thanks to the scrutineers was carried unanimously.

SIR HENRY TRUEMAN WOOD proposed a hearty vote of thanks to Mr. Alan A. Campbell Swinton, F.R.S., for his services as Chairman of Council during the past two years. He had served under about twenty-five Chairmen of Council, he said, and he really did not think there was any one who better deserved a vote of thanks. In spite of Mr. Campbell Swinton being a very busy man, he had devoted himself, heart and soul, to the work of the Society, and had been most assiduous in attending the meetings of the council and committees, as well as in presiding at various meetings of the Society. Perhaps he might also be allowed to mention that, as a memento of his having held the office of Chairman of Council, Mr. Campbell Swinton had presented the Society with an extremely handsome silver inkstand, which he felt sure the Council, when they knew of it, would very much appreciate.

MR. CARMICHAEL THOMAS, in seconding the vote of thanks, said he had served under a good many Chairmen of Council, and it had been a great pleasure to him to serve under Mr. Campbell Swinton. He fully agreed with every word Sir Henry Trueman Wood had said as to the deep interest Mr. Swinton had taken in the work of the Society.

THE CHAIRMAN, in acknowledging the vote of thanks, said that in no previous sphere of work had he met with such an exceedingly pleasant governing body as the Society's Council, and his two years of office had been a great pleasure to him. He should vacate the chair with much regret, and with the feeling that he had gone through a happy experience.

The meeting then adjourned.

LONDON RETAIL BUSINESSES.

An interesting article in the *Economist* of June 14th mentions that last year sixteen of the large London stores and shops made net profits amounting to £2,396,614, compared with £1,210,358 in 1914. The following table shows the net profits of each of these concerns in 1913 and in 1916-7-8:—

Company.	1913	1916	1917	1918
	£	£	£	£
Army and Navy	193,739	210,097	241,366	283,680
Civil Service Supply	44,911	48,363	55,722	54,434
D. H. Evans	69,923	59,005	69,318	94,465
Dickins and Jones	60,406	50,788	66,105	100,198
Frederick Gorringe	33,222	39,543	49,992	57,812
Harrods	295,181	235,046	282,293	352,042
Jay's	40,857	15,197	15,917	39,846
John Barker	63,907	66,001	85,284	101,298
Liberty and Co.	61,534	37,787	61,619	99,047
Maple and Co.	206,930	158,051	285,401	463,159
Mappin and Webb	54,250	30,380	46,780	66,975
Selfridge's	112,396	206,962	240,832	322,825
Spencer, Turner	37,194	56,623	55,675	74,578
Swan and Edgar	16,948	34,021	39,365	35,932
Thomas Wallis	23,118	30,656	33,241	59,761
William Whiteley	70,632	66,823	77,745	191,562
	1,385,050	1,345,343	1,706,655	2,396,614

Even when allowance is made for shops and stores selling necessities it is, says the *Economist*, difficult to explain away the tremendous increase in businesses of silversmiths, jewellers, and purveyors to our dilettantes. As pleasant reading in the midst of the "orgy of profiteering" the writer refers to the remark made by the head of one of the big shops that its percentage of gross profits in 1918 was decidedly less than usual, and of the claim advanced by the chairman of another huge company as to the smallness of its gross profit. After reviewing the financial position of the various companies named the article concludes:—

"The trend of the future is difficult to foresee. One great store—Selfridge's—is developing its organisation by absorbing large provincial houses, while Harrods has invaded the Continent, establishing branches in Brussels and Antwerp. But as against these extensions, other stores are developing the extensive business which they already do through the Post Office."

CULTIVATION OF CAROBS IN ALGERIA.

The cultivation of the carob, for which the climate of Algeria is very favourable, has recently attracted increased public attention in that country. The importance of this product as an auxiliary source of food for live-stock, especially in a country where cereal and forage production and pastureage vary much from year to year according to climatic conditions, is becoming more generally understood.

Like the olive tree, the carob tree grows in Algeria in a wild state. To encourage the grafting of carobs the Algerian Bureau of Agriculture distributed among the farmers of the colony who planted or grafted carob trees in 1916 a bounty of half a franc (5*d.*) per tree planted or grafted, with a maximum of 150 francs (about £6) per proprietor.

Carob cultivation in Algeria is largely localised in the environs of Bougie. A considerable number of trees are now grafted, and the product of these trees is said to be almost equal to the carobs of Cyprus and Crete. The greater part of the trees, however, are not grafted. Other parts of Algeria producing the carob are Palestro, Port Gueydon, and Cherchell. The carobs in these regions are not so fine as those of Bougie, and although nearly all grafted, have not the merits of the last named.

The exportation of carobs from Algeria is of importance. They are chiefly exported to France and Great Britain. The following table shows the total quantities of carobs, with their respective values, exported from Algeria during the last six years for which statistics are available:—

	Metric tons.	Value. £
1911	4,769	22,000
1912	6,922	37,400
1913	2,658	12,200
1914	3,004	12,800
1915	3,144	15,800
1916	3,852	19,400

According to a report by the United States Consul at Algiers, the relatively easy and remunerative market which will doubtless be enjoyed by the North African colonies during the next few years, should have a salutary influence on the development of carob cultivation. Italy and Syria, and the islands of Cyprus, Malta, Crete and Sicily, all of which have a climate somewhat similar to Algeria, cultivate the carob much more extensively. In these countries the carob has a very wide use as food for animals, and is often utilised as a food by the people. Despite this, these countries have large quantities to export.

In the district around Marseilles, the principal French port for the importation of dried carobs, there are many farmers who have been accustomed for a long time, in the years when forage crops were deficient, to feed carobs to their horses and cattle. Although this custom has caused no harm, it has not invariably been carried out in the most judicious manner; that is, in a way to allow the animals to derive the most benefit from it. In the use of this substitute it is said that insufficient attention has been given to the particular composition of the fruit. It would be worth while, says the Consul, to make experiments to ascertain the exact degree of digestibility of this fruit in relation to different kinds of animals, to make comparisons between the different kinds of carobs to ascertain their respective values, and to determine the influence of the different stages of maturity. Analyses made about thirty years ago are said to be the only standards in existence at the present time. In these analyses it is shown that the age of the fruit and the state of development of the seed have a large influence on the nutritive value.

It may be pointed out that the dried carob is particularly rich in saccharose and glucose. These elements represent 30 to 35 per cent. of its weight. As against this it is rather poor in azotic substances. Starch represents from 4 to 10 per cent. of its weight, according to the age of the fruit.

The small amount of digestible azotic matter necessitates the use of other food substances with this substitute, so that the total quantity found in the original ration shall not be diminished. This point has not always been observed in practice. The large proportion of sweet substances makes this food an excellent one for horses, which, of all domestic animals, need them most. However, the carob can also be fed to cows and to sheep. As a food for horses, the substitution of carobs for oats should be made up as follows: For each kilog. of oats substitute 520 grammes of carobs and 520 grammes of bran. In substituting carobs for hay as feed for horses or ruminants, equal quantities might be taken if the hay is of an inferior quality. As a substitute for hay of good quality, a small quantity of bran should be added. For 5 kilos of good hay, 6 kilos of carobs and 250 grammes of bran should be substituted.

As dried carobs are very hard they should be softened by 48 hours' soaking before feeding them to animals. The water in which they have been soaked should not be thrown away, as it contains much sweet matter. It is said that 5 or 6 kilos of carobs can be given to horses without risk, the same quantity to cattle, and 1 kilo to sheep.

Method of Cultivation.—The seed, after having been previously soaked in water for several days, is sown in February or March in the place where the tree is intended to grow, or better still, in a nursery, in a well-worked soil. The seed germinates quickly, the young plant appearing in eight or nine days if the season is not too dry. If the season is dry, the seed should be watered carefully. As soon as the plant is 1 centimetre in diameter, it is transplanted and grafted. The transplanting is rather a delicate operation; to ensure a good growth, it is necessary to leave a clod of earth at the root of each plant and to water it during the summer.

Grafting is indispensable, as this tree is more often diœcious than polygamous; that is to say,

some roots produce only male flowers and others only female. This gives rise to a sterile condition, but the grafting process easily remedies this, and assures an abundant fructification and a maximum yield. The method is simple. Male plants are recognisable without difficulty by the colour of their leaves. If the plant is female, only one male cutting need be grafted. If, on the contrary, the plant is male, only one branch should be kept, and female cuttings grafted on to it. This operation should take place, as already stated, when the young carob plant is 1 centimetre diameter, and has reached a height of about 50 centimetres. After five or six years the carob should be planted in mounds at intervals of 15 metres.

The carob plant blooms in autumn, and the beans are picked the following autumn. To preserve them the beans should be laid out in thin layers so as to dry thoroughly. They can then be stored in heaps. If this precaution is not taken and the fruit is piled in heaps after being picked, it will become black and ferment.

In certain districts the carob tree will not bear cutting and pruning. Only the dead leaves should be removed. In other districts the plant must be clipped young, so as to reinforce the stem and to regularise the vegetation. It is usual to give it a bell shape, but care must be taken to remove all the cuttings, as they have a tendency to grow at the foot of the tree.

The carob, like the olive tree, in order to flourish and produce well, requires a light soil free from noxious weeds. If these precautions are taken, the production is very large. In a suitable place the carob tree grows rapidly and, when clipped, new branches grow in abundance. Its foliage is thick and it has a long life. The tree attains an average height of 7 or 8 metres. In Algeria, Spain, and Sicily, it is not infrequent to find the tree from 15 to 20 metres high.

It can be well understood that it is worth while cultivating such a useful tree. A carob tree in good soil produces from 4 to 8 kilos of carobs three years after grafting. After six years the production attains more than 50 kilos. In full growth one tree produces a minimum of 400 or 500 kilos of fruit per annum. In a rich, light, well-watered soil, where the plant can extend its numerous roots at will, the production from one tree sometimes exceeds 1,000 kilos, worth from 80 to 100 francs.

LIGHT AND COLOUR IN RELATION TO STAGE EFFECTS.*

There are few, if any, stages in this country really well lighted, yet the importance of proper stage lighting can scarcely be overestimated. The relative values in order of importance are: First, the play; second, the acting; third, the lighting; fourth, the scenery; and fifth, the dresses. Stage lighting may be defined as the art of placing, or graduating, and of colouring light and shade.

The theatre, like other arts, was originally associated with religion, and in the early stages of their evolution religious ceremonial and dramatic representation are closely associated. Historically the value of lighting was appreciated as early as A.D. 750 at the Byzantine Court, and in 1160 we find sconces of candles used in miracle plays, flares and squibs especially being employed to give local colour to the devils. It was not until 1556 that Edward VI. granted his players a definite structure in which to produce plays, and half a century later saw the birth of the Elizabethan drama. Yet artificial lighting was practically unknown in England until 1682, when Sir Christopher Wren built the first theatre, Drury Lane, and Inigo Jones contrived the stage mechanism. Candles were then used, and a "patent stage lamp" invented in 1785. At the Lyceum the æsthetic value of lighting was first completely studied.

To-day stage lighting is both a craft and an art, calling both for æsthetic perception and engineering skill. In the ordinary theatre light is still used in substantially the same way as the candles in 1775 and gas in 1880. Lighting is achieved by (1) the overhead batten, (2) the footlights, (3) Standard Arc lights, (4) bunches of glow lamps behind transparencies. The chief fault is the hardness of the unnatural shadows and lack of diffusion. Nature has two methods of lighting—by parallel beams from the sun and the light from the diffused sky. Old-fashioned methods quite fail to imitate the second form of natural lighting. A complete illuminating surface resembling the sky cannot easily be obtained. Mr. Gordon Craig, who used overhead inverted arcs some years ago, attempted to meet the difficulty, but did not illuminate the actor's face. The Fortuny system, utilising reflection from coloured sheets of silk, etc., is excellent both as regards delicate colour-matching and shadow effect. A tightly-stretched field of coloured silk, illuminated by white open arcs, returns a reflecting light which is strictly diffused and casts practically no shadow. This is the basis of the Fortuny system, and the results are very beautiful, since slow graduations of light can be used and colours mixed on the reflecting screen, just as an artist mixes the colours on his palette. Escape of reflex light is guarded against by the use of black velvet, which has a coefficient of reflection of only 2 per cent. Of special beauty is the Fortuny "firmament," which may consist of a semicircular wall painted azure blue, and stretching from the floor of the stage, well above the line of sight of the auditorium. The drawbacks to this system are that it requires a specially-designed theatre, involves much loss of light by reflection, and means high cost of maintenance.

At the Court Theatre I have tried to produce the diffusion of the Fortuny system by less complex methods, by using a series of gas-filled lamps of

* Abstract of paper read before the Illuminating Engineering Society by Mr. J. B. Fagan, of the Royal Court Theatre.

1,000 candle-power at an angle of 45 degrees, coloured by gelatines and rendered semi-indirect by treated glass screens. The footlights are also indirect. To imitate the Fortuny artificial sky, a large semi-circular cloth painted azure, up high, but shaded to grey in the lower parts, is used. This is likewise illuminated by tilted 1,000 candle-power gas-filled lamps, spaced to give uniform illumination. Semi-indirect movable lights are also used on the stage. There are, however, still difficulties in getting the requisite uniformity of tint and gradual changes of colour in imitating sunlight and sunrise. The method, however, seems to mark a distinct advance.

The art of stage lighting is assuming an importance second to none. The great success of Rheinhardt's productions lay in his power of synthesising ability and combining the skill of the painter, the sculptor, the engineer, and the psychologist. Stage lighting may be said to be unnatural, but all art is unnatural; yet art is not of necessity crude or grotesque. To see an actor with four shadows round, as it were, in the centre of a gigantic St. Andrew's cross, is highly grotesque and disturbing, whereas to see him with one unnatural deep shadow may be improbable, but yet beautiful. The whole question of lighting in relation to stage effects deserves most careful study.

DECLINE IN LABOUR EFFICIENCY IN GERMAN MINES.

While attention is being drawn in various quarters to the fact that the individual output of coal per miner in this country is considerably less than in pre-war times, it is interesting to observe that a similar phenomenon is taking place in Germany. According to the *Zeitschrift für angewandte Chemie*, in the coal-mining district of Upper Silesia the output per man per shift was before the war 1·3 tons. During the war this efficiency dropped to 0·8 per ton. The decline has continued, till now it is only 0·5 ton, and in some mines only 0·4 ton. Thus the production per man is only one-third of what it was in pre-war days. Put in another way, three men are now required to do the work which formerly was done by one. And the rate of pay is more than double that received by the one in pre-war times. Thus the cost of production is enormously increased. In present circumstances, with old contracts still running, the cost of production in some instances amounts to 40 marks above the selling price. Clearly this great loss cannot long be borne by the mine-owners. Hence a great upward bound in prices is to be looked for.

In Western Germany, in the Essen district, the average daily wage for all hands at the mine rose from 5·29 marks in 1914 to 11·23 marks in 1918, an increase of about 135 per cent. The output per man per shift fell in the last three months of 1918 from 1·05 tons to 0·780 ton.

GENERAL NOTES.

American Machine Tools for Europe.—*Canadian Machinery* gives particulars of a proposal at present under consideration by the United States Government, which may solve the problem of re-equipping many French and Belgian factories and at the same time dispose of about 75,000,000 dollars' worth of surplus machine tools which the War Department has on hand. It is suggested that these tools should be turned over to French and Belgian manufacturers, the necessary credits being established through inter-Government financing. The disposal of these tools in the United States has been arranged for up to a certain point; but the problem is vast, and the disposal of the equipment in the manner indicated would be an easy and speedy solution, although it is admitted that it would ruin the prospects of many exporters of machine tools who are counting on considerable Belgian and French business. A great deal of machine tool business may be expected to go to America from Belgium, especially as that country has placed an embargo on the importation of German tools, which will not be removed even after the peace treaty has been signed. Practically the only competition America will have to meet, therefore, will be from Great Britain.

Trade with China.—Although China is suffering from serious constitutional and political troubles which must keep the country in a state of unrest for some time to come, the Chinese Ministry of Agriculture and Commerce is preparing to take advantage of better days—when they come. It has lately, according to the *London and China Telegraph*, inaugurated several measures to this end, one of which is the proposed appointment of Commercial Attachés to Great Britain, France, Japan, and the United States. It is important that the Chinese Government and traders should be kept well informed as to business conditions abroad, with a view to the extension of Chinese trade with foreign countries. It is well known that China has many products which the world requires, and with the necessary development and energy large and profitable sales could be effected. It is to the interest of foreign traders that China should increase her export business, since by this means she would be enabled to make larger purchases from them.

New Industries in India.—Recent ventures in Calcutta include "Thornycroft (India), Limited," with a capital of Rs. 24 lakhs for putting the motor vehicles and motor-boats of Messrs. John I. Thornycroft & Co., Ltd., on the markets of the East, and a company for the erection of new motor and engineering works at Asansol, Bengal. A Swiss embroidery company is also being established.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—June 27, 1919.

No. 3476. JULY 4, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

All communications respecting Advertisements should be addressed to the ADVERTISEMENT MANAGER, 97, GRESHAM STREET, E.C. 2.

Journal of the Royal Society of Arts.

No. 3,476. VOL. LXVII.

FRIDAY, JULY 4, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Monday, June 30th. Present:—

Sir William Duke, G.C.I.E., K.C.S.I. (Chairman of the Committee), in the chair; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.; T. J. Bennett, C.I.E., M.P.; Sir M. M. Bhownaggree, K.C.I.E.; Laurence Currie, M.A., J.P.; Sir Frederic W. R. Fryer, K.C.S.I.; Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc.; Sir H. Evan M. James, K.C.I.E., C.S.I.; Sir Charles Campbell McLeod; with G. K. Menzies, M.A. (Secretary of the Society), and S. Digby, C.I.E. (Secretary of the Section).

EXAMINATIONS.

The results of all stages of the examinations held from April 7th to 16th have now been sent to the centres concerned.

In the Advanced Stage 772 papers were worked. Of these 102 were awarded first-class certificates, 348 second-class certificates, and 322 failed.

In the Intermediate Stage the number of papers worked was 3,130, with 421 first-class and 1,659 second-class certificates; the failures numbered 1,050.

In the Elementary Stage 6,984 papers were worked. The passes numbered 4,487, and the failures 2,497.

In 1920 the first, or Easter, examination will commence on Monday, March 22nd, and will finish on Wednesday, March 31st. The second, or Whitsuntide, examination will commence on Monday, May 10th, and finish on Wednesday, May 19th. Detailed time-tables will be issued shortly.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Tuesday, May 27th, 1919; Senator the Hon. GEORGE FOSTER PEARCE in the chair.

The paper read was—

SCIENCE AND INDUSTRY IN AUSTRALIA.*

By LIEUT.-COLONEL THE HON. SIR JOHN McCALL, K.C.M.G., M.D., LL.D.,

Agent-General for Tasmania.

I have consented to read this paper before the Royal Society of Arts because a distinguished professor of a Canadian university has contributed one on "Science and Industry in Canada," and it appears to me that it would be wise to have one from each Dominion. It is not for any pleasure it can give you to listen to the reading of such a paper, but the records of this Society are always to be seen, and for those requiring information about the Dominions they are very valuable.

The early development of Australia was brought about by the growth of the primary industries. The country is very large in comparison with its small population; its area is 3,000,000 square miles, and its population just on to 5,000,000. It is as large as Europe without including Russia, and larger than the United States. The country extends from Tasmania in the south, where the temperature is cool and moderate, to Northern Queensland in the tropics, so that it embraces a great variety of climate. Australia and Tasmania have millions of acres to offer wheat-growers, dairymen, orchardists, and live-stock husbandmen. The value of some of the primary products for the year 1915-16 will be interesting, and also a statement of the agricultural resources, for there is no doubt that so far the backbone

* The announcement that Sir John McCall died on June 27th of pneumonia, at the age of fifty-eight, has been received with deep regret. He was appointed Agent-General for Tasmania in 1909, and shortly after his arrival in this country he became a member of the Colonial Section Committee, in whose work he showed great interest. He gave the Society two papers besides the one read by him on May 27th—"Fruit Production in the British Empire" (1910) and "Land Settlement within the Empire" (1917). He also frequently took part in discussions at the Society's meetings.

of Australia has been found in its landed industries.

	£
Value of agricultural production . .	73,768,701
,, dairy and poultry products .	21,155,826
Wool and sheepskins exported . . .	30,106,282
Value of mineral production . . .	23,567,302

The area under crop was only 18,528,234 acres, and consequently about one per cent. of the land of Australia returned just on £150,000,000 for the year.

It is wonderful what development has taken place without scientific education: not that there is now a lack of scientific observation and application in working the land, but in the early days very few of those settled on the land had any experience. Education has been free and compulsory for many years; high schools have been established, and now each State has its own university and each university is becoming a centre for research, so we have a better educated land-worker. The result of this has been demonstrated in many ways. Large areas of land supposed in the past to be valueless have been made highly productive either by special treatment or by special use. One third of Australia—roughly, 1,000,000 square miles—has a rainfall of over 20 inches; there is another area that we may call the intermediate belt, also consisting of 1,000,000 square miles, and this has a rainfall of from 10 to 20 inches; the remainder or centre third has less than a 10-inch rainfall.

The area with the large rainfall may be said to be the agricultural and dairying country; the area with 10 to 20 inches can be described as the wheat and sheep belt, and the centre of the great Continent is purely a pastoral area. The production in these enormous areas of land, which were easily obtained by the settlers, soon reached a point of over-production in wheat, wool, meat, dairy products and fruits. The wheat and wool were produced cheaply and were much wanted in this country, so there was no difficulty about exporting them as they were not perishable products. The production being so cheap, the freight to this country has not prevented the further development of the wool industry. Sheep and cattle run on the natural pastures and do not require winter housing or any of the special care and attention required in this and other countries The merino wool is the best in the world, and the breeding of stud sheep has become quite an industry in Australia and Tasmania. During the war period I had visits at my office from Tasmanians who had just arrived from South America and South Africa, where they had taken stud sheep from Australia. They wanted to know where they could join the Australians in the war, but in spite of all the money expended on education in Australia, and the usual broad-mindedness of its people, they had to be told that the Australian Force was closed to any Australian out of Australia. The breeding of stud rams is a highly profitable business for those who understand the industry, and some rams have realised as much as £3,000 and many sheep have been sold for £1,000 each. Wool and wheat then could be produced easily, and this, together with the fact that there was no danger of over-production, led to the production of these lines being continued in greater quantity than any other. I should say that this was so, until it was recognised that refrigeration and cold storage was going to allow us to send meat, butter and fruit to this side of the world and place on your tables these delicacies in almost as good a condition as if they were quite fresh. Science has worked wonders for Australia in this department, and enabled her to send you butter, cheese, frozen lamb, beef, pork and fruit, and these in increasing quantities until the war prevented the trade owing to shortage in shipping. Now, however, that our trade is to be restored again, we may expect to see in the production of all these lines an enormous increase. The men of the war who have lived in the open air under conditions which must make a return to their old life distasteful to them, are anxious to go out; and, added to the number of our own men who wish to go on the land, they will enable us to send much more food to Europe.

Australia is very proud of her share in establishing the cold storage trade with this country; and Tasmania, long before she came into the Commonwealth, established the shipment of great quantities of apples and pears to this country by means of refrigeration. Freezing works have been established over many parts of Australia; recently enormous works have been erected in the Northern Territory for the purpose of dealing with cattle from the runs in the north and sending the beef to Europe.

In connection with butter-making, for many years we made a large amount of variable quality, which, though eatable when perfectly fresh, rapidly deteriorated; then in the eighties we started butter factories. These were generally created by our own people and a few

intelligent farmers in each locality, but the bulk preferred to "stand by" and watch events. They could not grasp such cold facts as that "it would take three gallons of standard milk testing 3·6 butter fat to make one pound of butter under their hand-separating method, whilst the factory could produce a better and more uniform article from 2½ gallons." Now, however, we are able to ship large quantities of factory-made butter every year to this country.

Potato-growing, for which the north-west coast of Tasmania is famous, requires expert consideration. There, when the land is first cultivated, big crops running up to 16 or 18 tons to the acre are obtained, and in course of years these are reduced to about four tons. The crops in this country are maintained at a fairly high standard of ten or twelve tons to the acre. Here is a field for the expert to ascertain why we have this falling off in production. Is it from wrong fertilisers being used, want of proper change of seed, or what can the cause be? The land is a rich chocolate basaltic soil, and the reason must be found by scientific research.

There are other industries connected with the land. Take, for instance, wine culture. The vineyards of South Australia, Victoria and New South Wales are growing and profitable. There is no doubt a great field here for lucrative work, and as the wines are matured they will find a ready sale in this country. Already one learns that the demand exceeds the supply. Unless Australia runs the "dry bone" policy, wine production will eventually be one of its greatest industries.

Tobacco-growing is also making progress, and as the Commonwealth is giving a bounty of 2*d*. per lb. for all tobacco leaf worth more than 1*s*. per lb., its success should be assured.

Then there is flax-growing; this product, like tobacco, does not give as easy a living as the other land industries, such as potato-growing, dairying, etc. When Australia is peopled as fully as no doubt it soon will be we should have at least two or three million acres of flax grown in the country.

Sugar-growing in Queensland has with protection proved a success, and now we practically grow all our sugar requirements.

Beet-sugar is not produced to any extent in Australia, though there is little doubt that to grow sugar beet would be an excellent thing for the ground; this is on trial in Victoria.

Irrigation is possible over large areas of Australia, and already a number of schemes have been carried out. Mildura, to mention one, before the irrigation scheme was carried out, was nothing but a sheepwalk; now the 12,000 acres support a population of about 6,000, and a total production of fruit valued at £600,000. There is much to be done by irrigation, and it will be done as our population increases.

Railway construction has greatly helped in developing the country; there are over 21,000 miles of railways owned by the Governments of Australia, and about 3,000 miles owned by private companies. The bulk of the latter have been built by mining companies under the authority of the various State Parliaments.

Harbours are numerous; some large, natural harbours, like those of Sydney, Hobart, Albany; others requiring great expenditure to make and maintain.

Now we acknowledge all that has been done by science in helping to develop our great Australia. Let me enumerate some of the items: Breeding of sheep; irrigation; railways and roads; natural fertilisers; cold storage and refrigerated deep-sea carriage; and harbour accommodation. We must surely see that we want to encourage the Research Bureau established by the Commonwealth Government, and agricultural colleges set up by the States. By educating those who are settling on our lands we shall get better and quicker results in its proper development.

Let us now turn to the mineral wealth of Australia: gold, silver, platinum, osmiridium, copper, tin, lead, zinc, antimony, bismuth, manganese, chromium, tungsten, molybdenum, vanadium, and titanium exist in great quantities, also coal and iron ores. Building stones, such as granite, limestone, marbles, slate; ornamental stones, as jaspers, agates, rock-crystal, etc.; precious gem stones, as diamonds, opals, sapphire, turquoise, garnet, topaz, and many others. Sands, clays ranging from the finest kaolin or china clay to brick clay, are found in Australia. Polished marble of great beauty may be seen in Australia House in the Strand, together with native woods and other products of Australia.

Economic Metals.

Iron.—Iron is found widely distributed in Australia. From the iron knob in South Australia the Broken Hill Iron Smelting Works, in New South Wales, draw their iron ore. These works turn out the best steel and promise

to do much to enrich Australia. At the Blythe River there is a great bedded lode of hematite, cut by the Blythe River. The assays of this ore give a return of 66 to 72 per cent. of metallic iron with only slight traces of impurities. The Commonwealth Government have taken an option over this mine, and it is hoped that they will work it and make galvanised iron and tin plates; there are plentiful supplies of both zinc and tin in the State.

All the metallic alloys required to make steel hard, tough and elastic, are obtainable in Australia.

Copper exists in large quantities in Queensland, West Australia, South Australia, and Tasmania. In the last State the Mount Lyell is the largest producer of copper; it has already produced over £14,000,000 worth. The total production of Australia to the end of 1916 amounted in value to £75,674,072.

Lead and Zinc.—The greatest production is from the Broken Hill Mines in New South Wales. The total yield from Broken Hill amounts to £96,483,336 in value up to the end of 1917. These ores are rich in silver and zinc. Most of this metal was under contract sold to the Germans before the war, and thanks to the attitude taken up by Mr. W. M. Hughes, these contracts were broken, and Germany is not to be allowed to get them again. Efforts are being made in this country to deal with a large proportion of the concentrates from which the zinc is extracted, and a fair quantity will be dealt with in Tasmania electrolitically. The works for this treatment have been erected near Hobart, and are now extracting the zinc. There are other works to be erected in Tasmania to treat the complex zinc ores found in large quantities on the west coast of that State.

The total value of silver, silver-lead, etc., produced to the end of 1916, was £85,650,487. The Proprietary Mine, Broken Hill, has yielded £45,768,375.

Tin.—This is mined in all the States, both in lodes and alluvial ground. The Mount Bischoff Mine has yielded over £5,000,000 worth. The total from all over Australia is £35,453,227. The tin production from known deposits is likely to continue.

Gold.—Gold-bearing lodes and alluvial deposits exist on the east, north, south, and west of the Continent, and in Tasmania. The discovery of rich gold in Victoria over sixty years ago, led to a great influx of population. More recently big goldfields have been worked in Western Australia, whilst each State has made a contribution to the total output of nearly £600,000,000. One mine in the west —the Great Boulder—has had an output of over 110 tons of gold, worth £11,377,950. In Victoria gold has been worked to a depth of over 4,500 ft. below the surface, and it has been found over 6,000 ft. above sea-level. Lumps of gold, or "nuggets," have been found weighing over 200 lb. In Queensland the famous Mount Morgan Mine has been working for years for gold and copper, and gold is known to exist over a large area of the State, and also in the Northern Territory.

Silver.—This is produced by the ton at Broken Hill in New South Wales, and is widely spread over the Commonwealth. In Tasmania, at Zeehan, many silver-lead lodes have been worked and given good returns. A fair amount of silver is produced, together with gold, in the Mount Lyell Copper Mine. At present only a few silver lodes are being successfully worked in Tasmania. Much silver is known to exist in the Commonwealth, and its production will go on for many years.

Platinum.—This is being profitably produced in New South Wales. Osmiridium occurs in a number of the States, but is only found in large enough quantities to be successfully worked in Tasmania.

Coal.—Enormous deposits of excellent coal occur in New South Wales. Large reserves also exist in Queensland, and the coals of both these States give a first-class coke suitable for metallurgical purposes; this has been proved so far as the Newcastle coal is concerned. In Victoria large deposits of brown coal are known to exist, and some coal mines are worked by the Government. It is proposed to utilise the enormous deposits of brown coal which exist only a few miles from Melbourne, to produce electric power. Quite good household coal is found in South Australia, West Australia, and Tasmania.

Oil Shale.—Large quantities of rich oil shale, yielding up to 150 gallons of crude oil per ton, occur in New South Wales, and in Tasmania large deposits of shale exist. Both in New South Wales and Tasmania it is proposed to work these deposits for the production of oil, petrol, etc.

That the amount of gold produced has been reduced during the last few years is owing to the fact that this metal is the standard. The price of fine gold is fixed at about £4 per ounce, whilst the cost of every article used in producing gold, including labour, has

increased. If gold had not a fixed price, its value at this time would have been probably over £6 per ounce. The total value of minerals to the end of 1916 is over £900,000,000, and the number of miners employed is about 70,000. The future of mining is assured, and with the manufacture of articles from locally-produced metals the local consumption will be increased enormously.

Now let us turn to the manufactures going on in Australia. In 1850 there were only 2,000 people engaged in this way; to-day there are 330,000 persons in Australian factories, with an annual output of some £170,000,000. The manufacturing industries are growing fast; 13,000 factories in 1908 had grown to 16,000 in 1913; in the same period there was an increase in output from £99,500,000 to £161,500,000. The industrial possibilities of Australia are being recognised and rapidly extended. The Commonwealth Treasury have recently authorised public issues amounting to £2,500,000 for the extension of steel works, and the manufacture of white lead, zinc, woollen yarn, hosiery, cement, etc.

The possibilities of an export trade are great from Australia's geographical position in relation to the Dutch East Indies, the Federated Malay States, Japan, India, Siam, and last, but not least, China. The total population of these countries amounts to over 600,000,000. To secure the trade of these countries, it would be wise of the Commonwealth to obtain the services of a trade representative of the highest integrity, who could be appointed as a High Commissioner in the East. I am assured by the greatest British authority in the East that an enormous trade awaits us there.

Industries.

Of new industries one of the latest is shipbuilding. The Commonwealth Government have contracts in New South Wales, Queensland, Victoria, South Australia, and Tasmania for the construction of a number of steel steamers, and also for a number of wooden ships. When these are completed and added to their existing fleet, together with others being built for them in America, they will have in all at least sixty ocean-going steamships, in addition to a number of small coastal vessels. The engines, steel, etc., are practically all being made in Australia.

Woollen.—With our enormous production of wool it seemed ridiculous to think that we should export it to this country, have it manufactured here and again carry it out and pay a high import duty on the manufactured article. There are already a large number of woollen mills in Australia making goods for the local market, but there is room for many more. The war prevented the natural expansion of this trade, but now that it is possible to procure plant a great extension of old mills will take place, and some of the large manufacturers of this country are going to build mills behind the tariff wall. I do not doubt that when the local requirements are satisfied, a good opening for the export of our woollens will be secured.

Flax and cotton industries are promised. The Advisory Council of Science and Industry have encouraged a great increase in the amount of flax grown in Australia; at present the fibre is reserved for Great Britain, but as the amount increases no doubt for a start we shall manufacture canvas and duck; large quantities of both are annually imported into the country. Experiments are being made to devise a mechanical cotton-picker to save the cost of handpicking and should this be successful cotton-growing will certainly be taken up in a big way.

Chemicals.—An important scheme is now receiving attention for the manufacture of caustic soda. Superphosphates are being manufactured in large quantities, also sulphuric acid. Eucalyptus oil of excellent quality is produced in large enough quantities not only to satisfy the local demand but also for export.

Tin-plate, etc.—Now that we have the steel industry established in Australia we may soon expect the enterprising people who have done this to start wire-drawing and making tinplate. I understand that arrangements have been made to start a factory of sufficient capacity to supply Commonwealth requirements—estimated at something like 1,000,000 boxes of tinplate per annum.

The manufacture of arsenic for use in "dips" for stock and the poisoning of rabbits is being successfully carried out. It is proposed to obtain asbestos fibre from the rock and to manufacture asbestos goods from our own fibre instead of importing them. The manufacture of carbide has been started in Tasmania, where they have cheap electrical power. The factory, it is said, will produce 5,000 tons a year—about a third of the annual importation before the war. The company found trouble with the electrodes imported from this country and have built a factory for making their own electrodes; this is now working successfully.

This calcium carbide is made by fusing together coke and lime at a great heat produced electrolytically, and from it, by the addition of water, acetylene gas is given off and is used for lighting and other purposes.

When we realise what has been done in other countries where the electric power is cheap and carbide has been manufactured, we may look forward to an enormous enterprise growing out there by which nitrogen will be fixed in the form of cyanamide or nitrolim, making one of the best if not the very best fertiliser known. In the United States over £20,000,000 is being expended on this industry. In Germany nitrogen has been converted into nitric acid and used in the production of such explosives as guncotton, nitro-glycerine, picric acid and T.N.T. The fixation of nitrogen no doubt enabled Germany to continue the late war for years longer than she could have done without it. With a fertiliser at the Midland Agricultural and Dairy College, Kingston, it has been demonstrated that the return given in potatoes and mangolds shows a wonderful increase in production. At Rothamsted an outlay of 17*s.* 6*d.* gave a return of £9 per acre on potatoes, of 10*s.* 6*d.* in the case of oats secured £1 13*s.* 9*d.* At Kingston, in the case of mangolds, 1½ cwt. granular nitrolim cost only 1*s.* more than one cwt. of sulphate of ammonia, but that shilling brought in over £4 worth of mangolds at £1 per ton. While helping the growth and acting as a stimulant to the young grain in its early struggle for life, it absolutely destroys charlock—a very nasty plant pest. That the production of nitrolim is destined to increase the production of the food of the world is settled beyond any question; there can be no possible doubt, and it is a matter of much satisfaction for us to know that it can be manufactured in Australia.

Works are also being erected in Tasmania for the manufacture of sulphate of lead (electrolytically) for the purpose of making white-lead paint. In Victoria a plant has been erected in connection with paper-mills for the electrolytic manufacture of material required for bleaching purposes from salt obtained locally.

Some of the industries I have referred to have been encouraged by the war; others have been forced upon us by the great war—for example, the making of assay apparatus, students' chemical balances, metric weights, dispensing balances, retort stands, crucible tongues, blow-pipes, bunsen burners, etc. It has been found that all these things can be sold cheaper than when we depended upon Germany for them. Mainly as a result of the war we have the manufacture of ferro-alloys, especially for axles and wheel centres for railways and tramways, engineer's valves and plumber's fittings and accessories, electrical switches, carbon and gauze brushes, the recovery of tin from tin-plate scrap, the manufacture of cardboard containers, brass and copper tube drawing, and the manufacture of mechanical tractors for agricultural purposes. In Tasmania a large plant for the evaporation of apples has been established, and I am now receiving inquiries for these dried apples from Finland.

In Queensland an up-to-date plant has been constructed for paper-making.

Perhaps one of the greatest forces for industrial development has been established in Tasmania. There we have great lakes, situated some thousands of feet above sea-level. The Government have erected turbines, and convey the water so as to obtain a fall of over 1,000 feet. Electricity is generated and carried to Hobart, and already great works have been erected to treat the zinc concentrates from Broken Hill and the west coast of the State, and in addition we have the carbide works already mentioned. This power is sure to call into existence electro-chemical works which could not have been established without this cheap power. There are many other sources of power in different parts of the State, which the Government propose to harness. This work has no doubt led to a strong industrial feeling being spread throughout the Commonwealth, and possibly it caused the Commonwealth Government to give consideration to the subject of scientific development in Australia. Whether it was the cause or not, it is a fact that they have established an Institute of Science and Industry to carry on scientific research, a Bureau of Commerce and Industry to organise industry, and a Board of Trade to advise the Government where executive action relative to industry is sought, and the actual supervision of such things as the butter pool, etc. This proposal treating them as one was made by the Prime Minister, Mr. Hughes; he is the Chairman of the Institute, and has a committee of scientific men to carry on the work. The objects of the Institute are: (1) To consider and initiate scientific researches in connection with or for the promotion of primary or secondary industries in the Commonwealth; (2) the collection of industrial scientific information and the establishment of a bureau

of information for the benefit of those engaged in industry; (3) the establishment of national laboratories; (4) the general control and administration of such laboratories when established; (5) to promote the immediate utilisation of existing institutions, whether Federal or State, for the purposes of scientific research; (6) to make recommendations from time to time for the establishment or development of special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades; (7) the establishment and award of industrial research studentships attached to particular institutions; (8) to draw attention to any new industries which might be profitably established in the Commonwealth; (9) to seek the co-operation of, and to advise the educational authorities and scientific societies in the States with a view to: (*a*) advancing the teaching of science in schools, technical colleges, and universities, where its teaching is determined by those authorities, (*b*) the training of investigators in pure and applied science, and of technical experts, and (*c*) the education of skilled artisans; (10) to report annually and from time to time to Parliament.

It will be seen from the foregoing that the Institute will have plenty of useful work to perform, and may render the Commonwealth great service. Already in flax-growing they have been the means of securing a much bigger output, and they have even in their short life—starting as they did in 1916—more than paid for their full costs. They have appointed committees in each State, and established scientific libraries in two, the intention being to do the same for all the States. In this work I believe I am right in saying that the Commonwealth and State Governments are of one mind. They have already issued valuable bulletins on agricultural research, on the alunite deposits of Australia, ferro-alloys and alloy steels, power alcohol, wheat storage, etc.

The Bureau of Commerce and Industry are engaged in arranging for the organisation of industrial activities. They will aim at the establishment of key industries, standardise products, develop overseas markets, investigate trades, and obtain commercial intelligence for the benefit of those engaged in developing trade. Further, they may make investigations into any trade: (*a*) for the purpose of the tariff, (*b*) for the purpose of ascertaining the nature and volume of waste products, so that the question can be dealt with by the Institute of Science and Industry, (*c*) for the purpose of facilitating and cheapening transport on land or sea, (*d*) for the purpose of establishing key industries essential to any trade, and (*e*) for the purpose of ascertaining how far standardisation in any industry makes for economy and production. The Board of Trade investigate all problems involving trade interests, and are to advise the Government on such matters. They are also to consider the possibility of producing articles of which the supply is short, such as tin-plates, kerosene, shellac, etc.; further, they are to advise about the possibility of making up for short space in shipping. Though the Institute, Bureau, and Board, are separate entities, they are to co-operate for the public good. I have no doubt but that they will effect wonders, and I feel that Australia will have much to thank Mr. Hughes and his Government for in establishing the Institute, Bureau, and Board of Trade.

I have tried to write a readable paper, but fear I have not succeeded, and must thank you for your patience in giving me so good a hearing. I ask the Society to publish with my paper some figures which I have obtained from the book of Mr. Knibbs, the Government Statistician —the *Official Yearbook*—and which it would only weary you if I were to attempt to read.

STATISTICS.

	Horses.	Cattle	Sheep.	Pigs.
1860.	431,525	3,957,915	20,135,286	351,996
1915.	2,377,920	9,931,416	69,257,189	753,693

Value of net exports of principal pastoral products in 1915-16:—

	£
Horses	185,183
Meat	4,172,997
Skins and hides	194,358
Tallow	436,225
Wool	26,693,953

With the addition of glycerine, hair, hoop, horns, etc., the total value amounted to £33,558,093.

In 1914 the amount was £41,436,861.

(Of amount imported into the United Kingdom, 46 per cent. was from Australia and 26 per cent. from New Zealand.)

Area under crop and under sown grasses: 18,528,234 acres under crop, and about 3½ million acres under sown grasses. Of the acreage under crop, 12½ million acres were in wheat and 3½ million acres in hay. The value of the 1915-16 crop of wheat, exclusive of straw, amounted to £40,335,698. Barley: Value of crop for same year, £655,917, and quantity of potatoes 332,704 tons. Area under sugar-cane for 1915-16, 164,285 acres; the yield of sugar for that year being 1,310,264 tons.

Commonwealth vineyards for 1915-16: 62,124 acres, and output of wine 5,887,073 gallons.

Raisins and currants dried in the same year

amounted in Victoria and South Australia to 26,883,696 lb. of raisins and 15,352,288 lb. of currants. In addition there was comparatively a small lot dried in New South Wales and Western Australia.

Orchards and fruit gardens—acreage 247,008 acres. All kinds of fruits are grown, including the tropical banana, oranges, pineapples, and in the temperate zone apples, pears, apricots, etc.

Particulars of the principal kinds of fruits grown in the Commonwealth during the season 1915–16.

	Bushels.	Value. £
Apples	6,594,039	1,188,695
Apricots	616,342	220,899
Bananas		194,139
Lemons	300,001	116,886
Nectarines and peaches	908,561	309,871
Oranges	1,386,195	478,007
Pineapples	925,825	100,505
Pears	1,037,907	230,811
Other fruits		722,731
Total—165,925 acres		£3,562,544

Jams and jellies. There were 22,849,553 lb. exported in 1915–16, valued at £437,144.

Cattle and dairy cattle in 1915: Dairy cattle, 1,684,393; all cattle, 9,931,416.

Production of milk	432,767,460 galls.
„ butter	137,672,313 lb.
„ cheese	15,829,226 „
„ condensed or concentrated milk	26,977,000 „

Estimated value of poultry and eggs, 1915–16: £4,903,538.

Production of minerals in 1915, excluding cement, brick clay, etc.:—

	£
Alunite	5,680
Antimony	65,264
Bismuth	32,996
Coal	4,277,592
Coke	313,241
Copper	3,035,890
Diamonds	707
Diatomaceous earth	1,350
Gems (unspecified)	600
Gold	8,270,339
Gypsum	18,034
Iron	267,000
Iron oxide	3,774
Ironstone flux	302,048
Kaolin	3,108
Lead (pig, etc.)	739,411
Limestone flux	73,896
Manganese	2,258
Molybdenite	62,007
Opal	6,903
Platinum	476
Salt	80,000
Scheelite	4,121
Shale	12,890
Silver	372,038
Silver-lead ore (concentrates, etc)	2,402,805
Tin	806,641
Wolfram	76,667
Zinc	1,111,712
Unenumerated	47,334
	£22,396,728

CLASSIFICATION OF MANUFACTURING INDUSTRIES.

CLASS I.—*Treating Raw Materials, etc.*

Boiling-down, tallow-refining, etc.
Tanneries.
Woolscouring and fellmongering.
Chaff-cutting, etc.

CLASS II.—*Oils and Fats, etc.*

Oil and grease.
Soap and candles.

CLASS III.—*Stone, Clay, Glass, etc.*

Bricks and tiles.
Glass (including bottles).
Glass (ornamental).
Lime, plaster, cement and asphalt.
Marble, slate, etc.
Modelling, etc.
Pottery and earthenware.

CLASS IV.—*Working in Wood.*

Boxes and cases.
Cooperage.
Joinery.
Saw-mills.
Wood-turning, etc.

CLASS V.—*Metal Works, Machinery, etc.*

Agricultural implements.
Brass and copper.
Cutlery.
Engineering.
Galvanised iron-working.
Ironworks and foundries.
Lead mills.
Railway carriages.
Railway and tramway workshops.
Smelting.
Stoves and ovens.
Tinsmithing.
Wireworking.
Electrolytic zinc.
Other metal works.

CLASS VI.—*Food and Drink, etc.*

Bacon curing.
Butter factories.
Butterine and margarine.
Cheese factories.
Condensed milk.
Meat and fish preserving.
Biscuits.
Confectionery.
Corn-flour, oatmeal, etc.
Flour mills.
Jam and fruit canning.

Pickles, sauces and vinegar.
Sugar mills.
Sugar refining.
Aerated water, cordials, etc.
Breweries.
Condiments, coffee, spices, etc.
Distilleries.
Ice and refrigerating.
Malting.
Tobacco, cigars, etc.

CLASS VII.—*Clothing and Textile Fabrics.*
Woollen and tweed mills.
Boots and shoes.
Slop clothing.
Clothing (tailoring).
Dressmaking and millinery. (Makers' material. Customers' material.)
Dyeworks, and cleaning.
Furriers.
Hats and caps.
Waterproof and oilskin.
Shirts, ties, and scarfs.
Rope and cordage.
Tents and tarpaulins.

CLASS VIII.—*Books, Paper, Printing, etc.*
Electrotyping and stereotyping.
Paper-making, paper boxes, bags, etc.
Photo engraving.
Printing and binding.

CLASS IX.—*Musical Instruments, etc.*
Musical instruments and sewing machines.

CLASS X.—*Arms and Explosives.*
Arms and explosives.

CLASS XI.—*Vehicles, Saddlery, Harness, etc.*
Coach and wagon building.
Cycles.
Perambulators.
Saddlery, harness, etc.
Spokes, etc.

CLASS XII.—*Ship and Boat Building and Repairing.*
Docks and slips.
Sailmaking.
Ship and boat building and repairing.

CLASS XIII.—*Furniture, Bedding, etc.*
Bedding, flocks, and upholstery.
Billiard tables.
Furniture and cabinet making.
Picture frames.
Window blinds.

CLASS XIV.—*Drugs and Chemicals, etc.*
Chemicals, drugs, and medicines.
Fertilisers.
Paints, varnishes and by-products.

CLASS XV.—*Surgical and other Scientific Instruments.*
Surgical, optical, and other scientific instruments.

CLASS XVI.—*Timepieces, Jewellery and Plated Ware.*
Electro-plating.
Manufacturing jewellery, etc.

CLASS XVII.—*Heat, Light and Power.*
Electrodes.
Coke works.
Electric apparatus.
Electric light and power.
Gasworks and kerosene.
Lamps and fittings, etc.
Hydraulic power.
Carbide.

CLASS XVIII.—*Leatherware.*
Leather belting, fancy leather, portmanteaux, and bags.

CLASS XIX.—*Minor Wares.*
Basket and wickerware, matting, etc.
Brooms and Brushware.
Rubber goods.
Toys.
Umbrellas.
Other industries.

DISCUSSION.

THE CHAIRMAN (Senator Pearce), in opening the discussion, said that as one who had seen something of the developments of which Sir John McCall had spoken, and as a member of the Government which had been dealing with some of the questions involved, he had listened with very great appreciation to the paper. The war had done a great deal to develop Australia's secondary industries, because the Commonwealth was cut off from its old sources of supply, and had had to fall back on its own resources. There had been one or two things which had certainly opened their eyes to the possibilities in Australia, and he thought that they had been able to work them out in a manner beneficial to the country. He would like to indicate roughly the things to which he referred. There were three industries which came to his mind—the iron, timber, and textile industries. The Broken Hill Proprietary Company had rendered a very great service, not only to Australia, but to the Empire by its practical patriotism. He put it in that way because there were probably many more tempting ways for the investment of capital than some of the things they took up during the war. There was a very big element of risk in what they attempted. That it had turned out successfully was all to the good. They took up the manufacture of steel, first of all turning out steel rails, with which they were able not only to supply the requirements of Australia, but to send quantities to South Africa. By doing this they relieved the demand for rails from the United Kingdom, and thus enabled the industries in England to concentrate

more closely on producing war supplies. From that they went on to lay down a rolling plant. The plates and the steel generally, which were being used in the ships now under construction, some of which were as large as 10,000 tons, were, to the extent of 60 per cent., made from Australian ore in the mills laid down by the Broken Hill Proprietary Company after the war commenced. Then take the timber industry. Although it had magnificent timbers Australia used to import great quantities made up into furniture. As owing to the war Australia was unable to import the furniture it wanted, it had to use its own timbers for the purpose. To-day one would not see, in the Australian shops, any furniture made outside Australia. The Australian-made furniture was equal to any they ever had, beautiful in appearance and capable of quite as good finish as any in the world. As to the woollen industry, Australia turned its mills entirely on to war production. The fillip thus given to the textile industry was such that, now that it was possible to obtain the plant, he knew of no more promising investment. At the present time Australia was able to produce tweeds at a cheaper rate than was possible in the United Kingdom, the home of the textile industry. The British Government, during the war, were doing their best to supply the enormous demand of the armies in the field for high explosives, and went to the Commonwealth Government (and he presumed that they went to the Government of each of the Dominions) and asked them to do their best to assist. The Commonwealth Government called together a small committee of scientific men, who pointed out that Australia could help by producing toluene, glycerine, and acetone, and they were produced from things previously wasted. By following the advice of the committee, they were able to extract the light oils and the toluene from the tar, and the distilled tar was just as good for all the purposes for which it had previously been used in Australia. Then in regard to glycerine, they had been pouring hundreds of thousands of pounds' worth of glycerine from soapworks down the sewers. They were able, with very little expenditure, to save that glycerine, and to send it to South Africa. In their sugar industry there was a waste product —molasses—which had been poured into the rivers, serving no purpose but poisoning thousands of fish. The committee showed that from those molasses could be made acetate, which, with lime, formed the most important constituent of cordite. To-day, on the Brisbane River, there was a factory producing acetone in this way. Research was being carried on by the Institute of Science and Industry, with a view to manufacturing alcohol for power purposes from the same by-product. If such a large amount of work was the result of a small committee in a short time, what scope there was for scientific research and the application of science to production in the great continent of Australia. It was because of the openings which existed that the Commonwealth Government decided, not only to establish the Institute of Science, but to provide it with adequate funds. He was very glad to have that opportunity of recognising the very great debt of gratitude due to the scientific men of Australia for their assistance in helping to win the war. If such results could be obtained in time of war, they could be obtained in time of peace. Science came to the rescue of the Empire and helped to win the war, and, if it was assisted, it could help to win the peace and to effect the reconstruction about which people were so anxious at the present time. Public opinion in the past had been lethargic, if not hostile and sceptical, with regard to the value of applied science in production. Sir John McCall's paper would do something to remedy this state of things, and he was glad to have had the opportunity of being present to listen to it.

Professor Henry E. Armstrong, F.R.S., said that he had the good fortune in 1914 to be one of the party of scientific men who went out to Australia on the occasion of the visit of the British Association. The tour was one of the most remarkably organised excursions in which he had ever taken part. He thought that the majority of the visitors were greatly struck by the outward appearance of the country; even the colour of the vegetation was something quite special and peculiar. From beginning to end the visit was one of extraordinary interest. Everything showed that the spirit of progress was at work. It was quite clear that Australia had made a very great advance during the war—great progress in the direction of helping herself in the matter of manufactures, in making use of her resources and from the point of view of realising that science was going to be of special value. The Institute of Research, which Mr. Hughes had done so much to bring into existence, was undoubtedly destined to play a very great part in the future. Sir John McCall had not referred, however, to the limitations, the difficulties, which met the beginner in Australia. It was a country where a man had to know how to work and to be prepared to work very hard, if he was to get on. He would like to point to one or two directions in which he thought the Institute should, at an early date, take action. There was a reference in the paper to the millions of acres which Australia and Tasmania had to offer to wheat growers. But in the case of Australia—he could not speak about Tasmania—much of the land offered to wheat growers was soil on which wheat could not be grown with advantage unless manured pretty highly. The matter was one which, he thought, required very careful attention, because, after all, if people

were going to exercise any forward outlook, they had to consider what were the materials at their service throughout the world, how they were going to share them, and the rate at which they were at liberty to use them up. Attention had been called, for example, to the great value of the cyanamide which could be manufactured. In producing it a great deal of power would be used. He took it that in Australia that power could only be obtained from coal. In Tasmania, he gathered, there was a very large amount of water-power available which might be used. Personally he should be inclined to forbid the production of cyanamide in Australia and to insist that it should be made in Tasmania as a means both of saving coal and of preventing water-power from running to waste. Such considerations should play a very important part. He ventured to urge that one of the first things to be undertaken in Australia was a very careful soil survey, so that the potentialities of the soil in different districts might be clearly understood. He hoped that Sir John McCall would tell the Australians that all who went from the United Kingdom to attend the 1914 meeting of the British Association were unable to speak in sufficiently high terms of the reception which was accorded to them.

The Hon. Sir John A. Cockburn, K.C.M.G., said that industry in Australia had always been the object of paternal solicitude on the part of the State. All attempts at exploitation by our late rivals and present enemies had always been met with more resistance in Australia than in England, although sometimes they had been successful even in Australia. He remembered that when the cement industry was being started in Australia the Germans offered to supply all the cement which the Government required for five years at ruinously low prices. The Government turned a deaf ear to them and said to the new industry, "The Germans have charged us so much during the past years; we will enter into a contract with you if you will supply us at the same rate." The contract was accepted, and the Germans were not allowed to cut the throat of the new industry. Science was very highly valued in Australia, but was not worshipped as an abstract ideal. In very few countries was there such a thing as the pursuit of science for its own sake. The doctrine of utility was very strong in Australia, and science was regarded as necessarily harnessed as a working horse to industry.

General Sir William R. Birdwood, G.C.M.G., K.C.B., K.C.S.I., said that he had known and loved the Australian soldier during the last four and a half years. He had realised what the Australian's capacities were as a fighting man, and could fully realise what his capacities would be as a citizen. The Australian soldier, he knew, was going back determined to develop his country to the very best of his ability. If his efforts as a citizen were anything like as good as they had been as a soldier, he would make Australia one of the grandest lands in the world. He was sure that the Australian forces very much appreciated the fact that the Chairman of the meeting, Mr. Pearce, had been able to come over from Australia to give them his advice and help as Minister for Defence. The whole of the Australian Imperial Force owed Mr. Pearce a debt of the deepest gratitude.

The Hon. W. M. Williams (M.L.C., Tasmania) said that the main thing which Australia wanted was population. If it had population it would go ahead to a very much greater extent than it had gone in the past. He was personally obliged to Sir John McCall for the paper, because he would be able to make use of it in England. It contained everything in a very concise form.

Sir Gerald Strickland, G.C.M.G., said that people in England did not realise that the attractiveness of Australia was so great that the best men went there. He had had the privilege of coming into personal contact with almost all the great enterprises in the three most progressive States of Australia, and he thought that they deserved every word of commendation which they received in the paper. The most enterprising young men of England could not do better than seek their fortunes on the other side of the world, and capitalists could not find a better place than Australia in which to invest their money.

Mr. Alfred Dickinson, M.Inst.C.E., said that there was no place in the world where hydro development could be carried on so cheaply as in Tasmania, and therefore there was no place where electric energy could be supplied at a cheaper rate. Of course, the price at which electric energy could be sold depended largely upon the capital costs involved in construction. The possibilities of hydro-electric development in Tasmania were second to none in any part of the world. It would, he believed, be possible ultimately to supply power for general industrial purposes at less than a farthing a unit there, and if manufacturers had not the sense to go to a place where they could get cheap power, there was no "go" in them, as people said in Lancashire. In Victoria, for years, he had been investigating the merits of brown coal, and his view was that no country had a more valuable product than the brown coal of Australia. In the first experiments brown coal was burnt like ordinary coal, but that was wrong. To get the best out of it, it was necessary to distil it. If the Australian Government would either encourage the development of the industry, or themselves develop it, with that product alone Australia

could become one of the richest countries in the world.

The Hon. Sir Thomas Mackenzie, K.C.M.G., in moving a vote of thanks to Sir John McCall, said the paper was one of the most excellent to which he had ever listened. It was simply a storehouse of treasure, and contained a splendid review of the situation in Australia. It would be of very great value to those who wished to have all the necessary information at their fingers' ends.

Major-General Sir Harry Barron, K.C.M.G., C.V.O., seconded the motion. Having been in Australia, he realised the enormous importance of filling that continent with emigrants from the British Isles, and he urged that every effort should be made to encourage emigration. Western Australia was practically a million square miles in extent, and in that million square miles there were 300,000 inhabitants, a number equal to the population of Bradford. It was foolish to allow such a state of things to continue. Every effort should be made to fill up Australia, New Zealand, Canada, and so on, without depleting this country of the population which it required.

The motion was carried unanimously.

Sir John McCall, in reply, said that he wished to assure Professor Armstrong that the messages which he desired to have carried to Australia with regard to the welcome received by the members of the British Association would be carried; but they would be carried not by him, but by Mr. Pearce. He wished to express his appreciation of Mr. Dickinson's remarks upon the subject of the very cheap water-power which existed in Tasmania.

MANUFACTURE OF PAPER FROM BAMBOO IN TRINIDAD.

An important project for manufacturing paper from bamboo in Trinidad is being carried out by an Edinburgh firm of publishers. About 1,000 acres of land near St. Joseph (seven miles from the capital at Port of Spain) have been planted in bamboo, and a concession has been obtained giving the firm the right to cut bamboo from the Government forests.

According to a report by the United States Consul in Trinidad, the firm in question, foreseeing a paper famine throughout the world within the next few years, have been giving serious consideration to the problem of providing adequate paper reserves for themselves for the future; and although realising that paper can be produced from any vegetable material containing cellulose, nevertheless came to the conclusion that bamboo was most suitable for the purpose. They selected Trinidad for their bamboo-paper project, as the bamboo grows there very quickly, having sufficient development within three or four years for making paper.

Experts have been employed to study the question of easily getting rid of the knots in the bamboo, and also of the yellowish-green colour that has hitherto been considered a drawback to the manufacture of paper from bamboo. The first experiments in Trinidad with the bamboo consisted of putting the reeds through sugar-cane presses. While this rather crudely accomplished the purpose, nevertheless it was found to be desirable that the bamboo should be shredded as well as mashed, and the knots removed. It is said that a machine has been designed which accomplishes all this work, and that a bleach or dye has been discovered which makes the pulp wood and paper perfectly white. It is understood that the machinery for the bamboo plant, to cost about £30,000, has been ordered from the United States.

DESTRUCTION OF FRENCH RAILWAYS BY THE GERMANS.

In an article in *Génie Civil* particulars are given of the destruction of railways, roads, and waterways by the Germans in the north and east of France. This is partly due to the actual damage by war, but chiefly to organised destruction designed to cripple French trade for as long a period as possible. The writer of the article quotes from a work, "Die Industrie in besetzen Frankreich" (Industry in the Occupied Districts of France), from which extracts are given.

Nine photographs are reproduced, showing the damage done at various important points. A report of the Ministry of Public Works, dated March 13th last, states that 2,900 kilometres of railway, comprising 5,600 kilometres of single track, were destroyed wholly or in part, as well as 1,510 bridges, 12 tunnels, and 590 buildings. Upon the Nord railway 1,966 kilometres (2,950 kilometres of single track), 250 stations, without reckoning those damaged by bombardment outside of the occupied zone, four tunnels, and 860 bridges of more than four metres in length, of which six were large viaducts, are in ruins. Cranes, signals, points, signal cabins to the number of 150, all the buildings in stations, the locomotive sheds, the water reservoirs, and the water services for locomotives, and even the houses of the level-crossing keepers, are ruined. The author enters into similar details for other lines, and the photographs show (1) the wreck of the passenger station at Charleville; (2) a bridge destroyed at Saint Quentin; (3) the same at Tergnier; (4) the same at Hirson; (5) the remains of the viaduct at Gland; (6) ruins of a road bridge at St. Quentin; (7) one pier only left standing of the viaduct of Blangy; (8) and (9) views of the station at Tergnier.

As to the roads, the Germans have made gaps upon 9,000 kilometres of the main roads, and upon 96,000 kilometres of the secondary roads, which

will need 10,400,000 tons of materials and the outlay of 320 million francs, in addition to 240 million francs already spent on repairs of the roads for military purposes.

As to the canals, the Germans mined the embankments, destroyed the syphons, the locks, the canal aqueducts, and in fact purposely did the greatest damage possible. The traffic upon the canals is rendered impossible for years.

USE OF YERBA MATÉ IN PARAGUAY.

Yerba maté, or Paraguayan tea, is made from the leaf of the *Ilex paraguensis*, a tree indigenous to Paraguay and to parts of Brazil and Argentina adjacent to Paraguay. The infusion has been used by the inhabitants of Paraguay as a beverage from the earliest days of which there is any record, and has also long been in use in the neighbouring Republics.

Tea made from yerba maté leaves is served in two forms, called "maté cocido," and simply "maté." "Maté cocido" is prepared from the yerba leaves identically as ordinary tea is prepared, and is served with sugar and sometimes with cream. "Maté" is made by placing milled or ground yerba leaves in a gourd (called in the Guarani dialect maté, whence the tea gets its name), or other small pear-shaped container, and pouring hot water over them. Instead of being served in cups, maté is sipped from the gourd in which it is made, through a silver or white-metal tube called a bombilla, the gourd and bombilla being passed from person to person, as each partakes through the same tube. The latter form of the tea is the one that is in general use among the natives of the country.

It is claimed that the tea produces better results when made in the gourd and served through the bombilla (which has a strainer on the bottom), than if taken as ordinary tea from the cup, but "maté cocido" finds favour with a great many people. Those who are familiar with the tea served in both forms state that it is just as satisfying to the taste as coffee or ordinary tea, that it produces a sedative rather than a stimulating effect when taken, and that the taste for it grows as one becomes accustomed to its use.

Parallel analyses of the properties of yerba maté, coffee, and ordinary tea, according to one authority, are as follows: yerba-maté, 12·28 per cent. tannin, 2·55 per cent. caffeine; coffee, 16·39 per cent. tannin, 2·66 per cent. caffeine; tea, 17·80 per cent. tannin, 4·3 per cent. caffeine. Another authority gives the properties of yerba maté as 7·24 per cent. tannin and 2·8 per cent. caffeine.

Paraguay's exports of yerba maté during the six years 1911–16 were as follows:—

	Kilogs.		Kilogs.
1911 . .	2,478,178	1914 . .	3,331,655
1912 . .	2,849,790	1915 . .	4,709,213
1913 . .	4,216,606	1916 . .	3,275,558

Argentina is the chief destination, though some tea is exported to Brazil, Uruguay and other neighbouring Republics. Only small quantities have been exported to Europe, principally to Germany.

The yerba maté production of the country is controlled chiefly by La Industrial Paraguaya, D. Barthe, and Gauthier & Co., all with head offices in Asuncion. The first-named company is an English concern owning 8,325 square miles of tea lands in Paraguay. It controls more than 60 per cent. of the entire yerba maté trade of this Republic. The other two companies control about 15 and 10 per cent., respectively, of the trade.

It appears from a report by the United States Consul at Asuncion, from which the foregoing particulars are taken, that the harvest season for yerba maté begins about January. Seeds, which are rather difficult to obtain, are gathered at this time for planting purposes. The plants require cultivation in order to produce proper results. The yerba maté leaves are prepared for the market in mills. No statistics of yerba maté consumption in Paraguay are available, but the quantity consumed is probably much greater than the amount exported.

PROLONGING LIFE OF WOODEN POLES.

Mr. C. R. Harte, writing in the *Electric Railway Journal*, describes various means of prolonging the life of wooden poles and discusses their relative advantages, whilst pointing out how different preservations keep out and destroy destructive germs.

The fresh sapwood of white pine is 50 per cent. water (of which 60 per cent. is sap, 35 per cent. is in the cell walls, and 5 per cent. is in the cell contents). The heart-wood contains a much smaller percentage of water, but what is there is sealed in so that it is difficult to eliminate. Preliminary soaking in water accelerates the rate of air-drying by removing much gum and mineral matter. Though the primary objects of seasoning are to cut down the food supply of decay fungi and render the wood more receptive to preservative chemicals, the reduction in weight is an important consideration from the point of view of freight costs.

Very careful temperature control is necessary with kiln drying, and the dried timber should be impregnated at once, to prevent reabsorption of moisture.

A prolonged series of measurements by the United States Forest Service shows that the external circumference of poles is practically unaffected by seasoning, even where there is heavy checking.

Oil paint protects a smooth dry pole against decay, but the paint is easily broken through, and does more harm than good to imperfectly seasoned poles by entrapping moisture. Tar gives a more elastic coating and some antiseptic effect, but the penetration is poor, and internal decay occurs almost as badly as with oil paint. Concrete sheathing is costly but effective, apparently owing

to absorption of salts from the green concrete. Charring is uncertain in action, weakens the pole, and increases the fire risk.

There are two groups of antiseptics, viz. mineral salts and oils. The great disadvantage of the mineral antiseptics is that they are soluble in water and are quickly leached out. The author discusses the characteristics of creosotes from other sources than coal tar, and describes the high pressure "full cell" and the "empty cell" methods of applying preservative. A table is given comparing standard specifications for various creosotes. Notes are included on the methods and special features of all other preservative treatments now in common use.

Methods are described for repairing poles already decayed at the ground line. Whether the old pole is repaired or a new one installed, it is important to sterilise the surrounding soil. The simplest method is to reinforce the weakened pole by setting a stub alongside.

OBITUARY.

The Right Hon. Sir John T. Brunner, Bt.—Sir John Brunner died on July 1st at his residence, Silverlands, Chertsey, from heart failure. He was born at Everton in 1842, and at the age of fifteen entered a Liverpool shipping office. Five years later he became works manager to Messrs. Hutchinson and Earle, chemical manufacturers, at Widnes. In 1873 he entered into partnership with Dr. Ludwig Mond, and began to make alkali under the Solvay system. The works of Messrs. Brunner, Mond & Co. are now among the largest of their kind, and Sir John Brunner remained chairman of the company up to the time of his death.

Mr. Brunner, as he then was, represented Northwich in the House of Commons in 1885, and again from 1887 to 1909, when he retired. He took a deep interest in the development of the country's industrial resources; he served on the Royal Commission on the improvement of Inland Navigation; and he was a generous friend to education and research, especially in connection with the University of Liverpool, where he endowed three chairs.

He was created a baronet in 1895, and a Privy Councillor in 1906.

Sir John was elected a member of the Royal Society of Arts in 1898, and he occasionally took part in discussions at the Society's meetings.

GENERAL NOTES.

Ministry of Health.—Under the provisions of the Ministry of Health Act, 1919, an Order in Council was made fixing July 1st as the day upon which the Act came into operation. On that day all the powers and duties of the Local Government Board passed to the Ministry of Health, the question of the transfer to other Government Departments of any existing powers or duties not relating to matters affecting or incidental to the health of the people being reserved for consideration and decision at an early date. All communications on subjects previously within the jurisdiction of the Local Government Board should accordingly henceforward be addressed to the Secretary, Ministry of Health, Whitehall, S.W. 1.

Railway Fares in Great Britain.—The Railway Executive Committee, in a recently-issued statement, point out that although the number of soldiers travelling now shows a considerable decline, more civilians are being carried than in 1913, notwithstanding the 50 per cent. advance in fares. There is no doubt, the committee say, that if the 50 per cent. were withdrawn the railways would be "quite unequal at the present time to cope with the traffic." But it remains to be seen whether any reduction in fares can be effected "when the freight rates are increased" and, presumably, additions are made to the rolling-stock.

Oversea Industrial Enterprise.—An All-Australian Exhibition is to be held in Adelaide next year, opening on March 26th and closing on May 22nd. The exhibition will consist of "works of artists, manufacturers, producers, mechanics, and all other sections of industries in which the Commonwealth is engaged." It is announced that, while the exhibition is confined to Australian manufactures, the committee would, from an educational point of view, be prepared to make provision for the display of models of aeroplanes, motors, machinery, new inventions, etc., from the United Kingdom.

Resettlement in the Highlands.—This is the title of a booklet issued by the Inverness Local Advisory Committee and obtainable at the "Courier" office, Inverness. It contains a great deal of information for those interested in the development of the Highland area. The machinery of resettlement, including the functions of local advisory committees and of the Scottish Employment Council, is described; and this is followed by chapters on transport and communications, water-power in industry, afforestation, small holdings, housing, fisheries, training for disabled men, the employment of women, and home industries in the Highlands and islands. As Lord Strathclyde remarks in a foreword to the pamphlet, there is much reconstructive work waiting to be done in the Highlands, and there are plenty of competent men and women ready to do it: the problem is how to bring the work and the workers into effective relation. It is to be hoped that the publication of the information contained in this handy form will do something towards a solution.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—July 4, 1919.

No. 3477. JULY 11, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

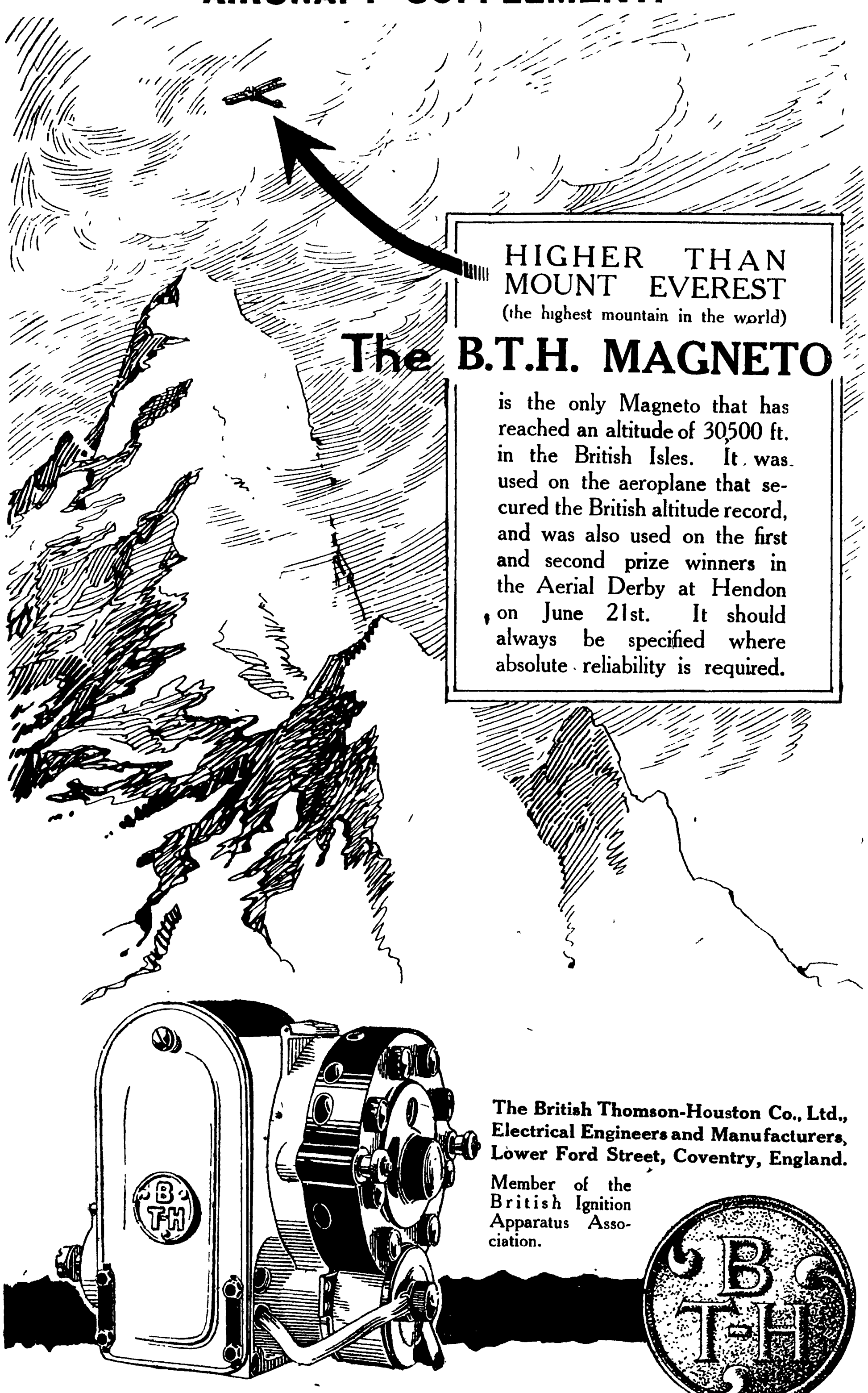
Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2.

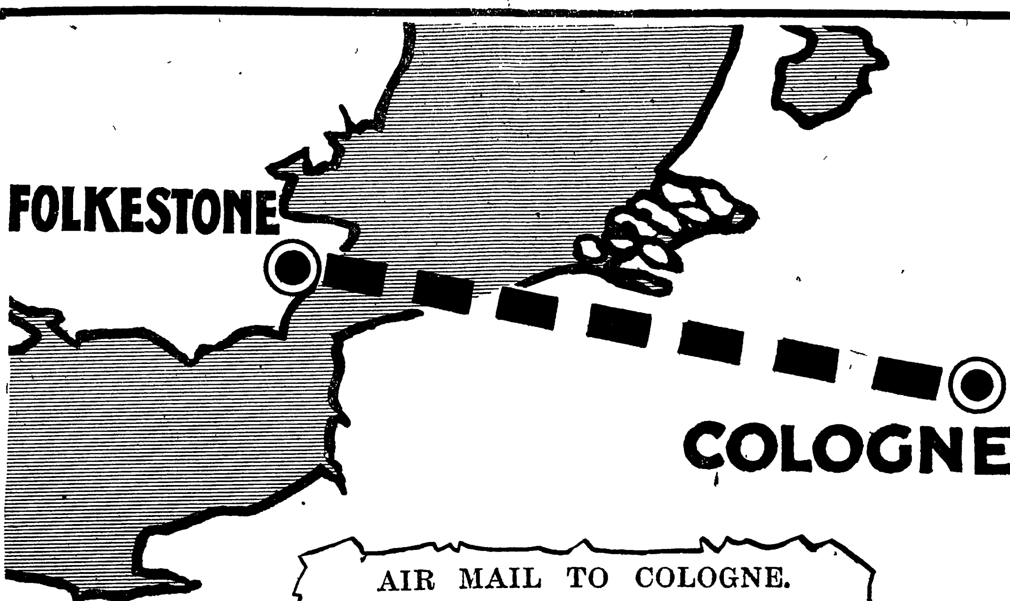
REGISTERED AS A NEWSPAPER.

AIRCRAFT SUPPLEMENT.



AIRCRAFT SUPPLEMENT.

AIRCRAFT SUPPLEMENT.



AIR MAIL TO COLOGNE.

SUCCESS OF FOLKESTONE SERVICE.

The daily aerial service between Hawkinge (Folkestone) and Cologne is proving very successful. The service was instituted on March 1 with four aeroplanes, which carried between them 25 bags of mails; but the mail has greatly increased, reaching the total of 2,276 outward and 886 inward bags for the three months ending May 31. The rapid manner in which the mails are handled on this side is illustrated by the fact that correspondence leaving Cologne one morning has been delivered to all parts of England and Wales from Folkestone by the first delivery on the following morning.

—*Times*, Saturday, June 21st, 1919.

The machines employed on the service referred to above are Airco 9's with B.H.P. motors and Airco 9A's with Liberty motors.

The management of the Aircraft Manufacturing Co., Ltd., will be glad to discuss with Dominions or Foreign Governments, firms or individuals, any proposal for the use of aircraft as vehicles for high-speed transport.

THE AIRCRAFT MANUFACTURING CO., LTD.

Chairman (and Founder, 1911): G. HOLT THOMAS.

London Office: 27, BUCKINGHAM GATE, S.W.1. *Works:* THE HYDE, HENDON, N.W.9.

AIRCRAFT SUPPLEMENT.

BRITAIN LEADS IN AIRCRAFT

NIEUPORT LEADS BRITAIN

BRITISH NIEUPORT & GENERAL AIRCRAFT CO., Ltd.

Telephone: Willesden 2455 (3 lines).

Office: LANGTON ROAD, CRICKLEWOOD, N.W. 2.

Telegrams: "Nieuscout, Crickle, London."

CONTRACTORS TO H.M. GOVERNMENT.

OUR Organisation, which has in the past been responsible for our success in the design and production of Naval and Military Aircraft, as evidenced by the Nieuport "Nighthawk" being chosen by the Royal Air Force to fill their latest requirements for Fighting Scouts, is now concentrating its energies on the development of Commercial machines. Above are depicted, reading from top of page, our—

1. Four or Six-Seater. An ideal family machine.

2. Two-Seater (side by side) and Single-Seater. These are excellent sporting machines, and would also be invaluable for training purposes.

3. "Nighthawk," which is being delivered in large numbers to the Government.

4. Finally, 14-Seater Passenger Machine, which has a spacious saloon to accommodate 12 passengers.

Enquiries are therefore solicited from Governments, Companies, and individuals interested.

Journal of the Royal Society of Arts.

No. 3,477. VOL. LXVII.

FRIDAY, JULY 11, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, June 5th, 1919; Major-General the Right Hon. John E. B. Seely, C.B., C.M.G., D.S.O., M.P., in the chair.

The paper read was—

AVIATION AS AFFECTING INDIA.

By Brigadier-General Lord Montagu of Beaulieu, C.S.I., F.R.Met.Soc., F.R.G.S., A.Inst.C.E., A.I.Mech.E.,

Adviser o Mechanical Transport Services to the Government of India.

The idea of the magic carpet came from the East, but the writer of "The Arabian Nights" could hardly have imagined, when he translated the well-known fairy story, that within a comparatively short time, as the history of the world goes, aircraft would be its modern parallel. And, moreover, the East is more suitable for flying than what we know as the West, and in the whole of the East there is no country more suited to aviation than India. Whether the most important factor in flying, meteorology, be considered, or easily made landing grounds, or local supplies of liquid fuel, there can be but one conclusion, namely, that India is an ideal country for aviation. And if incentives are wanted, the land and sea communications of India, both internally and externally, leave much to be desired, and a table of railway speeds, which I give later on, shows how great would be the saving of time, even at comparatively slow air speeds, which the airplane should achieve. When one comes to consider also the communications between India and these islands, it is remarkable that certain circumstances, some of them commercial and some of them geographical, prevent anything approaching rapid communication being carried on between Western Europe and Indian ports.

It is a maxim now realised by everyone who has studied aviation, that the longer the distance the greater the gain of the airplane over other methods of transport. Whether we take the shortest possible direct route to India—say, 3,000 miles in length—or the longer journey now being used by way of France, Italy, Egypt, Palestine and Mesopotamia—some 5,000 miles in length—in either case many days are saved. As to airmails (carrying airgrams, as I would call them), when daily communication is established, it is safe to prophesy that the present block of several days' delay on the Eastern Telegraph Company will be relieved at once. I may remark in passing that the cable companies rather than the shipping companies will feel the competition of airplanes.

When we are considering the question of routes other than those by air, we must realise that the distances from Indian ports to English ports are much lengthened by the peninsulas of Spain and of Arabia, which jut out in such a way as to make the course from the Channel to India a zig-zag one, resulting in the distance by sea, about 6,000 miles, being about double the distance by air direct. Even by the most rapid mail route, *viâ* France and Italy, the distance from Bombay to London is nearly 5,000 miles, or 2,000 miles longer than the shortest air route. Then there are the necessary delays of the Suez Canal, say, twenty-four hours on an average.

When, two years ago, I prophesied that the England to India route would be the first long distance route to be accomplished, and that the accomplishment of it would be a landmark in the history of the world, and be the first useful long distance journey by air, there were

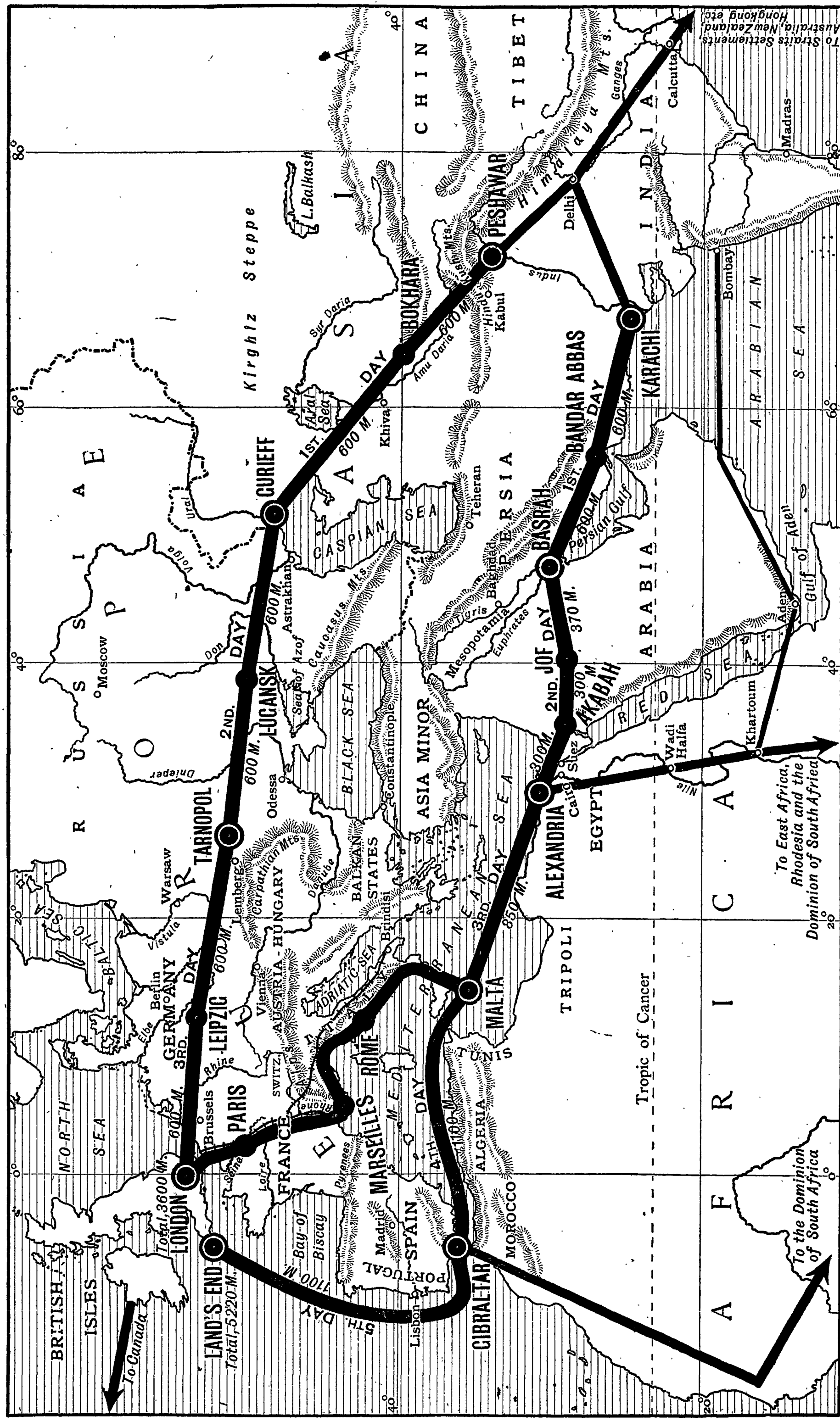
many who jeered, as people have always jeered at prophets in all times and in all countries. But already two Handley-Page machines, with Rolls-Royce engines, have accomplished this flight, about double the width of the Atlantic, and in a few months' time regular services will be established without any doubt. Flying across the Atlantic is a hazardous feat, where the odds are heavily against the pilot and machine reaching the other side. There is not only the factor of a long distance without a landing ground, but the drawback of normally unfavourable meteorological conditions in the North Atlantic. In the case of flying between England and India, however, there is now a long but well mapped out route, to some extent provided with insufficiently numerous but regular stages, landing grounds, and spare part depots. With the exception of the flight over the Channel, France and Northern Italy, no serious climatic disadvantages exist. As regards Imperial or international control, the present air routes to India pass, with the exception of France, Italy and Crete, entirely under the direction of the British Empire. Moreover, when India is reached, it is by no means a dead end, to use an old railway phrase, as some may think. India is half way between London and Australia, and beyond India lie many important parts of the Empire, such as Australia and New Zealand, Burma, the Federated Malay States, British Borneo, and Hong-Kong. The winter conditions in Siberia and Thibet will preclude regular flying from China and the East to Europe for many years to come, and the route south of the Himalayas is, therefore, certain to be used. Consequently the Northern Plains of India, from Peshawar to Calcutta, will become some day one of the world's greatest airways. I consider that Heliopolis (Cairo) will be the most important single centre of air transport for the Old World—Europe, Asia and Africa—for thence will radiate services to East, Central, and South Africa on the one side, and on the other to India and countries beyond. But next to Cairo in importance will be some Indian station for reception of all mails east of India to places ranging from Vladivostok to New Zealand.

As regards internal communications, India is a country of vast distances and of bad communications. It is inadequately provided with railways and roads. The average train speeds before the war, even including the usual one mail train each way a day, were very slow compared with ordinary European or American standards. Deficient locomotive power, inferior permanent way and weak bridges, besides natural difficulties, such as sandy deserts, stiff gradients, and acute curves, all tend to lower the average speed of long distance journeys in India. Mails were slow and are to-day still slower in delivery. While there is always a demand in a few commercial centres, such as Bombay and Calcutta, for quicker trains and mail services, the majority of the people of India outside the 200,000 British engaged in its administration and its commerce, is apt to be content with things as they are, and it must be admitted the average Indian tolerates slow trains and mails with complete equanimity, time being no object to the Eastern mind.

I set out in a table at the end of this part of the paper the time taken by the fastest Indian trains in October, 1918, between certain important centres, and also the time which would be taken by airplanes, at the low average speed of 70 miles an hour. I will give but one illustration here of how time might be saved in regard to the services between Simla, the political capital of the Government of India for eight months of the year, and Bombay, the chief seaport for Europe. Between Simla and Bombay there are two principal railway routes, varying from about 1,000 to 1,250 miles. The quickest journey to-day by either takes about forty-eight hours, or an average speed of about twenty-five miles per hour. The same distance could be flown by an airplane (at the rate of 70 m.p.h. as a minimum) in rather over fourteen hours, a saving of thirty-four hours out of forty-eight hours. On a journey from Peshawar to Calcutta, or from Peshawar to Bombay—longer distances—the saving would be proportionately greater; while a direct air route from Karachi to Delhi, across Rajputana, at present a matter of forty-eight hours journey by rail, would reduce the time taken to about ten hours.

In considering the matter of mails, and whether it would pay to fly them, it is a question, of course, how much the letter-writing public in India—a small number all told—would pay for increased speed, even if they would pay at all. But the answer to this question can only be ascertained after trial for some time, and will probably have to be considered in connection with passenger services, as is the case with the present mail train and mail ship services.

Another special aspect of flying within India itself should be considered, namely, if it is possible to set up regular passenger services



SUGGESTED ROUTES TO THE EAST.

between hill stations and the plains below, except, perhaps, during the months of November, December and January. Such services would give over-worked officials, civil and military, and their families, suffering from the effects of heat, an easier chance of constant recuperation in the hills for short periods, or even week-ends, without so large a proportion of time being absorbed as at present, in slow railway or road journeys. An illustration of this exists in the case of Kashmir. Rawalpindi, the railhead for the Kashmir road, is two hundred miles from Srinagar. Along this road, even in a powerful motor-car, high speeds are impossible, and, as a rule, most travellers have to put up with the delays and inconveniences of tongas, in which the journey generally takes two or even three days. An airplane, on the other hand, would cover the distance from the town of Jhelum (on the main line of the N.W.R.) to the Maidan, outside Srinagar, an ideal landing ground about eighty to ninety miles distant, in a little over an hour. From the same point to-day by rail and road, the time taken by the ordinary passenger exceeds fifty hours, even if a motor-car is used. If Kashmir is to become, in the future, more and more the playground and health station of the British race in Northern India during the summer months, such a passenger service by air would prove of immense value. The highest point through the Ferozepore nullah to be crossed over the intervening range, the Pir Panjal, is not higher than 8,000 ft., an altitude easily exceeded by all our larger bomb-carrying planes to-day, a type which is probably the forerunner of the passenger-carrying planes of the future

We must also consider other military and civil stations at high altitudes, such as Quetta. Those condemned to live during the summer months at stations in or near the Indus Valley, between Karachi and Multan, could in a few hours find themselves in the far cooler atmosphere beyond the Bolan Pass, or perhaps at a new hill station, say at Rusmuk in the Mahsud country. As regards Simla and other Himalayan hill stations, the problem of landing grounds is an admittedly difficult one. At Simla there is perhaps one landing ground possible, namely, Annandale, if it were improved for the purpose. But, on the other hand, very soon airplanes will be able to land on an area of ground equal to about four to six tennis lawns, and the Government of India could easily make, in many places, artificial small flat spaces ending in ramps. To Simla and other Himalayan hill stations come, in the hot weather, soldiers, civil servants, and civilians from all over India, and ease and speed of journey to their hill stations would be an invaluable boon. Hill stations, such as Mussoorie, Naini Tal, Dalhousie and Murree, as well as other hill stations, all present considerable difficulties in the matter of landing grounds; and though these difficulties may seem forbidding to-day, I am absolutely convinced that landing against an artificial slope, on a small piece of ground, will be soon a perfectly practical and everyday proceeding.

So long as external mails are conveyed by sea, and arrive at and depart from Bombay, the mail service to and from that port can be much accelerated, compared with the present train service. From Bombay to Calcutta, by the shortest railway route, is 1,223 miles, a journey of about forty-six hours. An airplane service from Bombay should cover the distance in about seventeen hours, a saving of about thirty hours each way.

I suggest that the most important internal routes in India are:—

1. Bombay, *viâ* Delhi and Lahore, to Peshawar.
2. Bombay to Calcutta.
3. Bombay to Madras.
4. Bombay, *viâ* Mysore, to Colombo.
5. Bombay, *viâ* Baroda, to Karachi.
6. Calcutta to Madras.
7. Calcutta, *viâ* Cawnpore, to Delhi.
8. Madras to Colombo.
9. Madras, *viâ* Hyderabad, to Jhansi, for Delhi and the north.
10. Peshawar, *viâ* Indus Valley, to Quetta and Karachi.
11. Delhi, *viâ* Bikaner, to Karachi.

As regards the control and organisation of flying in India, I have heard it argued that the Government of India should allow no private ownership of machines, and that no Indians should be licensed to fly. Though it is obvious that care must be taken that the planes owned by any individual are not capable of being used for hostile action against the community, such as bombing, or fitted with apparatus for machine-gun use, it seems to me very unwise to try to prevent the progress of aviation among any citizens of the Empire, Indians or any other peoples, who are keen to fly and able to possess their own machines. I would suggest, however, that at first landing grounds should be Government owned, but let to private companies if necessary, and regulations must be made to prevent any cause of offence arising

	Miles.	Hours.	M.P.H.	Airplane (70 m.p.h). (Hours.)	Time saved. (Hours.)
1. *Bombay to Peshawar, viâ* Delhi—					
(*a*) G.I.P. and N.W.R.	1,542	55	23	22	33
(*b*) B. B. and C.I.R.	1,450	53	27¼	20½	32½
2. *Bombay to Karachi, viâ* Baroda	992	46	21	14¼	31¾
3. *Bombay to Calcutta*—					
(*a*) E.I. and G.I.P.R.	1,349	43	31	19¼	23¾
(*b*) B.N. and G.I.P.R.	1,223	46	26½	17½	28½
4. *Bombay to Madras*	794	36	22	11¼	24¾
5. *Calcutta to Madras*	1,030	41	25	14¾	26¼
6. *Calcutta to Delhi*	903	28	32¼	12¾	15¼
7. *Madras to Colombo*	700	35	20	10	25
8. *Madras to Jhansi Junction, viâ* Dhond and Manmad	1,314	64	20½	18¾	45¼

from the use of airplanes. For instance, considering the excitability of Eastern crowds, it would be dangerous to allow flying to take place over sacred places, large towns, or over religious processions.

In entering India from outside, landings should only be permitted on Government controlled grounds, or otherwise smuggling may become troublesome. Pilots and their machines must be numbered and licensed, as suggested by the proposed international agreement.

I may mention that several of the great chiefs in India are already keen on aviation, and shortly we may see maharajas and rajas arriving in royal state at Delhi Durbars in gorgeously fitted airplanes, and relieving the over-congested Indian railways of their special trains or coaches.

Generally speaking, the less Government control there is over any new development in the world the better. The heavy, inelastic, and clogging hand of Government has rarely done anything in the history of this country to encourage new developments, and the Government of India, by its composition and nature, can never be extravagantly progressive. I would say, at the risk of being officially censured for daring to doubt its divine wisdom, that the Government of India had better encourage private enterprise in aviation than endeavour to manage all air services and operations itself.

How greatly meteorology concerns flying has not yet been generally realised. In India there are two distinct climatic periods in every year. There is the tranquil period of the north-east monsoon from October to May, and the more disturbed period during the south-west monsoon from the end of May to October. Owing to the use of free high altitude balloons we have been able recently to ascertain that the south-west current is comparatively shallow, rarely over 10,000 ft. in depth, and that above the clouds, which probably extend to about 8,000 ft., there is generally a clear sky. This fact may rob the monsoon period of many of its drawbacks. In winter, on the other hand, conditions are curiously dissimilar to the summer conditions. A light north-easterly wind blows over the surface of the Indian peninsula until a height of about 15,000 ft. to 20,000 ft. is reached. At that altitude a strong west wind, sometimes attaining a speed of 100 miles an hour, is encountered. Anyone who has watched in winter the high cirrus clouds over the northern plains of India will not be surprised at this feature. The majority of storms come from the west, and depressions can invariably be seen coming from that direction, especially near the frontier. As regards other weather conditions, dust storms are dangerous at times, but rarely affect the weather higher than 4,000 ft. to 5,000 ft. Dust devils, as they are called, those small erratic whirlwinds of local violence, are never, so far as my flying experience in India goes, felt above 3,000 ft. As regards the south-west monsoon period and the intense humidity prevailing then, no doubt special arrangements will be made to insulate all the electrical and wireless connections on machines. I have now called your attention to these insignificant drawbacks of the Indian climate, and it only

remains for me to state that from September to June, on nine days out of ten, the weather is perfect for flying, the visibility exceedingly good, and the average air currents under ten miles an hour in velocity.

It may interest you to know that in recent conversations with the Director-General of Posts and Telegraphs in India, Mr. Geoffrey Clarke, I learned with pleasure that he was strongly in favour of air mail services being started in India at once, and hoped that contracts would be sanctioned with private commercial companies rather than any attempt be made to work direct through the R.A.F. I am sure that no disparagement was intended in his mind as to the capabilities of the R.A.F. to undertake any work anywhere. But from many points of view a commercial company undertaking air mail services would be in a freer and more favourable position, while the risks inseparable from early development would not be borne by the Government of India. The Government of India should, in my opinion, make contracts with groups or companies really capable of carrying out their contracts in the same way as the sea mails are now confided to the care of the P. and O. Company.

I am often asked how soon passenger services by air will be established between India and England. In reply I would say, first of all, let us establish for at least a year regular postal services, for the experience gained thereby will avoid loss of valuable lives, and the discouragement which is bound to come when only a proportion of the hopes we set out with are realised. Moreover, I think it will be a long time before it is commercially profitable to fly passengers, on account of their weight compared with mails. The world is ready to pay much more per ounce for the rapid conveyance of information and news than it is prepared to pay for the transport of human bodies.

But, of course, a year hence, if money is no object, anyone will be able to fly between England and India, and in time the fares will be much reduced.

I have worked out the following figures to show the truth of this assertion Taking the average load of a man with a very limited amount of luggage as weighing 12 stone, this weight comes out at 2,688 oz. We will assume that airgrams pay at the rate of 2*s.* 6*d.* an ounce. If 2,688 oz. be taken in the form of postal matter we get a return of £336. Now a man would have to be very rich, or in a great hurry, to pay £336 for a passage between India and England, and the price is a prohibitive one to ordinary persons. At the price of 2*s.* 6*d.* per ounce of airgrams, the conveyance of a ton would return £4,480, and the airplane flying mails at this rate between England and India would, therefore, earn about £1 per mile by the present route. Against these receipts I venture to put the expense at about 10*s.* a mile, including all ordinary expenses, depreciation, and interest at 7½ per cent. on capital. As regards passengers only, it takes only thirteen and a third men to weigh a ton at an allowance of 12 stone for each man and baggage, and one can hardly imagine thirteen men, apart from the third of a man, paying collectively £4,480 for a passage between Karachi and London.

It is clear, therefore, that at first the main payable traffic by air must consist of what the Post Office calls "mail matter," and I am sure that the commercial world in India, here and elsewhere, when services become regular—the most important point of mail services—and rapid, will use air services very largely.

It is interesting to note that about five thousand words can be written on thin foreign paper and, with envelope and stamp, weigh just under an ounce in weight. Any such letter up to five thousand words in length could be taken the 5,000 miles, the present route, in forty-eight hours, and for 2*s.* 6*d.* A cablegram, on the other hand, of the same length would cost at present prices of cabling a rupee a word. It would take four to five days as a minimum : it would probably be somewhat mutilated in transmission, and cost £416, as against 2*s.* 6*d.*

I assume, of course, that the rate for internal mails in India is going to be a much cheaper one—namely, a maximum of 1*s.*, or, say, 12 annas for an ounce letter.

Then there is the use of photography for transmitting letters. A typewritten letter can be photographed in an exceedingly small compass, and enlarged again by the recipient. Probably at least 10,000 words could thus be sent for an ounce by this process.* *The Times* of a certain day could be thus reproduced in India within three days exactly as the original was published in Printing House Square.

The subject of flying, apart from mails, to India and in India, is so large a one that I must not let myself go into all the branches and aspects of it. But as to mail services to

* Concentration by photography can probably be carried on to one-fiftieth of the size of the original print or writing, and from this size enlarged again to any extent as large or larger. This idea opens up immense possibilities for the transference of news over long distances by air.

England, I would like to bring to your notice the fact that the present war route, *viâ* Cairo, Damascus, and Mesopotamia, is by no means the most direct, and that something like 1,000 miles would be saved by following a direct line from Cairo *viâ* Akabah to Basra, the distance being only 790 miles between Cairo and Basra.

As my old friend General Seely, the Minister now in charge of the R.A.F., is in the chair to-day, I would ask him to remember that India deserves some of our best pilots and machines. The time is past, also, when India should be looked upon as the dumping-ground for inferior airplanes, and I may remark that when I left India about two months ago we had not a single machine there which could have flown with safety over any height or pass exceeding 8,000 ft. The bombing, therefore, of Kabul, the capital of Afghanistan, from Parachinar, the closest point in our territory, only seventy-five miles distant, was impossible, because there was no machine in India which had "ceiling" enough to get over the intervening ranges, especially the Peiwar Kotal, fifteen miles west of Parachinar, which forms the frontier between British territory and Afghanistan. Bombing has had to be carried out, therefore, from the neighbourhood of the Khyber Pass, a much longer distance.

I need hardly say that the frontier will be held in future by airplanes, mechanical transport, and armoured motor batteries. These weapons of war connote good roads, and it is imperative, therefore, that good roads should be made and maintained on the North-West Frontier. I have done my best for four years to impress this fact upon the Government of India.

I would like also to put before you some of the problems we have to face in India with regard to engineering and construction. I must begin by reminding you that the Italians had, up to 1916, much more experience of the effect of fierce sunlight, especially of the actinic rays in sunlight than anyone else. Their campaigns in Tripoli have taught them much, and when I endeavoured to get the Government of India to order two dirigibles of the type known as M.6 from the Italian Government early in 1917, I pointed out to the authorities there that the Italian airships were, from the Indian point of view, the best that we could obtain then, on account of the special experience of the Italian Government in construction in tropical climates. Under the intense light and heat of India, there are four special problems of engineering construction which we have yet to solve:—

1. Engines that will not overheat in temperatures up to 180° F. in the sun, and 125° F. in the shade.*

2. Wood that will not get "short," as it is called, and perish or warp in a very dry climate.

3. Fabric that will not deteriorate and become weak.

4. Dope that will withstand extremes of heat and cold, and the destructive effect of intense light.

This is not the place to discuss at length the possible solutions of these four problems, but before flying can be permanently successful or safe in India, the best brains in the scientific world will have to be utilised to overcome these difficulties.

I am inclined to think that, as our knowledge of dirigibles improves, and we have learned much already, dirigible balloons will possibly be preferred as a means of conveyance of mails and passengers by air between England and India without any intermediate stop. A dirigible has already been 101 hours in the air without coming down, and I may mention that two and a half million miles were covered by dirigibles during the war with comparatively few mishaps. While we must all admit that the speed of the fastest dirigible is at present about half that of the fastest airplane, at the same time a continuous flight of 3,000 to 4,000 miles is already possible; time is saved by the absence of stops en route; and the dangers of sudden breakage or forced descent, or disaster in case of engine failure, are small.

I think, however, it may interest you to see how the journey by airplane might work out on the basis of ten stages:—

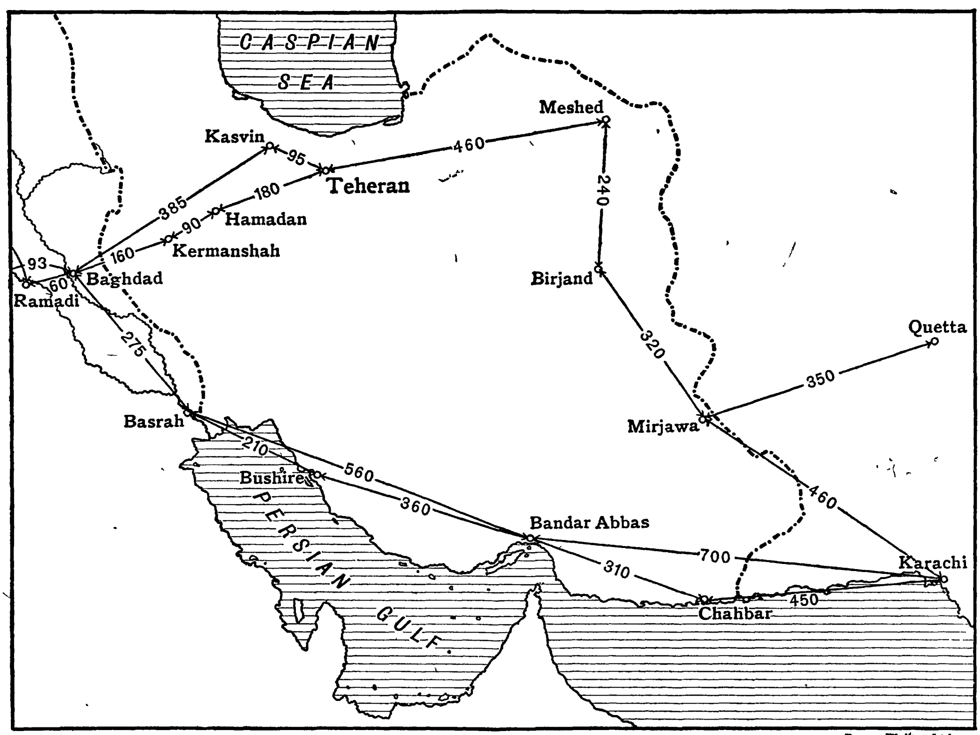
ENGLAND TO INDIA.

DISTANCES BETWEEN LANDING GROUNDS (Approximate).

	Miles.
Section 1.—London to Lyons.	
London to Paris	230
Paris to Lyons	280
Section 2.—Lyons to Rome.	
Lyons to Turin	200
Turin to Rome	350
or	
Lyons to Frejus	220
Frejus to Rome	450

* This problem chiefly concerns airplane engines while being tuned up on the ground, or running light before a flight is commenced. The temperatures of the hottest day in the sun, say 180° F., and of the explosion in an internal-combustion engine, say, 2500° F., are so far apart that there is not much difference in the cooling of air-cooled engines while in flight.

Section 3.—*Rome to Otranto.*	
Rome to Otranto	320
Section 4.—*Otranto to Crete.*	
Otranto to Crete	480
Section 5.—*Crete to Cairo.*	
Crete to Cairo (Heliopolis)	520
Section 6.—*Cairo to Damascus.*	
Cairo to Jerusalem	275
Jerusalem to Damascus	150
Section 7.—*Damascus to Baghdad.*	
Damascus to Hit	366
Hit to Baghdad	100
Section 8.—*Baghdad to Basra.*	
Baghdad to Basra	300
Section 9.—*Basra to Bandar Abbas.*	
Basra to Bushire	250
Bushire to Bandar Abbas	350
Section 10.—*Bandar Abbas to Karachi.*	
Bandar Abbas to Karachi	600



Emery Walker Ltd. sc.

MILITARY AIR ROUTES—MARCH, 1919.

Of course, more stages will mean a greater number of pilots and planes being employed, and, therefore, the shorter the stages the more expensive the establishment of the services.

Before I conclude I would ask you to carry your minds back less than eleven years, to the time when, in October, 1908, Wilbur and Orville Wright were flying at Le Mans, and to the stupendous—and that adjective is not nearly strong enough—progress made during the last five years under the stimulus of war, with the extraordinary incentives of unlimited money and unlimited man power. There has been also the dread of each nation of the other nation's aircraft, and the growing belief, a belief which I held from the first day of war, that of all the weapons used in the war, superiority of aircraft would be eventually the most decisive. I would also ask you to realise that the British Empire, scattered as it is all over the globe, is strategically weak and liable to attack at a given moment at many points far distant from each other. It needs, therefore, rapid and easy communications. The Empire of India is the most populous, the most important commercially, and the most vital to us, of all the great dominions of the Crown. India should, therefore, have all the advantages which may be derived from the use of aircraft as soon as possible. And, finally, in all our plans for the establishment of air services all over the Empire, we must remember that plenty of good aircraft in peace means a reserve of good aircraft for war. Whatever the

future of the world holds for the British Empire we must see that it is as supreme in the air in the coming years as it has been in the past, and is now, on the sea.

[A series of lantern views, reproducing incidents of the first flight to India, was lent for the occasion by the Air Ministry.]

DISCUSSION.

THE CHAIRMAN (Major-General J. E. B. Seely, M.P.) said the paper gave a vision of the future of almost surpassing interest. He had listened to it with peculiar pleasure for two reasons: firstly, because the author, owing to his wide knowledge of transport and travelling, and his official duties in India during the war, was specially qualified to speak on the subject; and, secondly, because although a prophet was apt to have a hard time of it in this world, the author had been a true prophet on a great many occasions in regard to flying. His lordship had hit the nail on the head at least three times when other people thought he was making a very bad shot. He was recently reading a little book published by Lord Montagu in 1907, when people thought that flying was impossible, in which the author referred to the effect of flying on the life of the community, and in particular on military and naval operations, and stated that it would be such as to revolutionise the world. All those statements had come true. Most astonishing strides had been made in flying within a comparatively short period, due, amongst other factors, to the skill of the designers and builders of aircraft, but perhaps first and foremost to the extraordinary valour, courage and determination of the pilots in these islands. The hearts of all present went out to those brave men who had blazed the trail and shown the way. Many of them, unfortunately, had lost their lives on active service in the course of defeating the enemy; but their lives were not given in vain, because it was largely to them that the victory that had been won was due. Since the armistice, the extraordinary advantage of air power on the military side as against the civil side had been proved in regard to the prevention of war. It was now known that air power was the best means of winning a big war and also of preventing a small one. He was recently told by a very distinguished officer that, looking back on the past, he was of the opinion that if this country had then possessed the air power which was now at its disposal, the great Indian Mutiny, the Afghan campaigns, the wars in Egypt and Nigeria and other parts of the world which had been waged against semi-civilised tribes would have been very much shortened—in fact, many of them would never have occurred at all. It was now possible within one day to convey to those concerned that they had better obey the will of those who wished to protect them from each other, as compared with the three weeks or a month in which it would be possible to organise a small expedition. He was told that the presence of a rather large aeroplane over Kabul a short time ago had a considerable effect in persuading the Amir of Afghanistan to modify the truculent views which he had expressed; and the appearance of that aeroplane over Kabul had probably saved the lives of thousands of our own people and, incidentally, also of the Afghans. But we were still a long way from being able to achieve all those objects by the use of the air alone; it was vital that the three Services—the Navy, the Army, and the Air Forces, each separate, but each interdependent—should work hand in hand to a common end. Given that they did that, he thought the air power of Britain, which he hoped would ever increase and grow, would be able to maintain peace throughout those parts of the world where it was our duty to protect the inhabitants from their own self-destructive designs. He saw a bright future for military aviation in the sense that it would do the best of all things militarily—prevent war. With regard to the civil side of flying, particularly the carriage of mails, speaking as one of those "heavy-handed, club-footed individuals" belonging to the Government of the day, he agreed with the author as to the enormous possibilities of rapid communication, especially to India and in India. The Air Ministry, while they hoped that in the future private enterprise would run the mails wherever possible all over the world, had decided that, in order to help the business on, they would, as soon as they could get all the machines necessary on the spot, start running a mail route from Cairo to Karachi. Arrangements were already in progress for carrying out that project, by means of which valuable lessons would be learned. It would be a good thing for private enterprise, because an endeavour would be made to find out the difficulties and dangers that existed, so that everything could be done to make flying more certain, more regular, and more safe. As to the future of flying in India, he could say nothing in regard to how far it would become general in that great peninsula. Speaking for himself, he thought it would be a great mistake to say that any one of his Majesty's subjects should be entirely debarred from flying. That would be a reactionary thing to do, which would probably defeat its own objects. Under proper restrictions for the safety of the community he saw a great future for aviation in India. The figures that had been given in regard to the climatic conditions were absolutely conclusive. It had been possible in these stormy islands to conduct a regular service from London to Paris with comparatively few accidents, and during the winter to run a regular mail from London to Cologne on 79 days out of 100. In view of what had been done in this country under such weather conditions, it was easy to imagine the enormous advantage there would be in the wonderful Indian climate, with much more stable conditions, and with the

airman's chief peril and dread, fog, absent almost completely throughout the year.

Sir Charles H. Armstrong (Chairman, Great Indian Peninsula Railway) said that, speaking from the commercial point of view, he was not quite certain whether in the future the airgrams that the author had referred to were likely to interfere much with telegrams. If an efficient air service was available at the present moment he was sure the commercial community in this country would be very pleased indeed to take advantage of it, because it now took sixteen days to get an answer from India to a telegram sent from this country. In normal times, however, it was possible in India to receive a telegram from London at 7 o'clock in the morning, to reply to it from, say, Bombay at 12 or 1 o'clock, to receive an answer from London about 6 o'clock in the evening and to reply again the same day. He did not think an air service could ever compete with such a telegraphic service, although it would be very useful for the carriage of mail matter. He was sure the author did not intend to make any reflection upon the railways in India, because they were now suffering very much from their inability to carry out renewals and repairs during the war. Now the war was over, repairs and renewals were being undertaken, and the trains would in future travel at a considerably higher speed. In his opinion an air service in India would be extremely useful for carrying mails between the large towns, such as Bombay and Calcutta, and Karachi and Bombay, and Madras and the various other big towns. There could be no doubt about it that there was a very great opening for aviation in India. The climate during many months of the year was entirely suitable, and under those circumstances there ought to be very rapid development of the industry. He also quite agreed that the development of aviation should be left to private enterprise, subject to such safeguards as might be necessary.

General Sir O'Moore Creagh, V.C., G.C.B., G.C.S.I., said that the introduction of mechanical transport into India had solved one great political difficulty in regard to the impressment of carriages for the moving of troops during the marching season. The zemindars and landowners very much resented their bullocks and bullock-carts being impressed at the season of the year when they were most required on the farms. The author had referred to the fact that it would be very easy in the future to get to the hills by aeroplane. As a very old inhabitant of India he had come to the conclusion that the improvement in means of transport had, unfortunately, meant less intercourse with the people. Before railways were laid down in India, British officers knew Indian people much better than they did at present. He hoped the fact that British people would be able to get to the hills in twenty-four hours would not adversely affect the mutual acquaintance of the people of India and British officers. If that was so, it would have the disadvantage of making British people gauge Indian opinion by their own, which was a very mistaken idea. As one who had lived mostly in the jungles, and who liked jungle life, he desired to say a word on behalf of his old friends of the jungle —the tiger, the deer, the bison and the bear. Before he left India, mechanical transport was used for the pursuit of those animals by people whom nobody would call sportsmen, because they did not give the animals a chance. He hoped the Government of India would be moved by all lovers of sport to bring into force a game law which would prevent the indiscriminate slaughter of the wild fauna of India by such means; otherwise it would be quickly exterminated. Sport was most valuable to the soldier; it taught him patience, attention to detail, and knowledge of the people of the country. With regard to the effect of aeroplanes on war, it was no doubt perfectly true that had aeroplanes existed at the time of the Afghan war in 1878, instead of that war lasting two years it would have lasted two months at the very outside, and much money and many vaulable human lives would have been saved.

Sir Charles Bright, F.R.S.E., M.Inst.C.E., believed that each of the various methods of communication, whether by aircraft, cable, wireless telegraphy, or telephony, had its own particular sphere of usefulness, and thought that an inquiry into the whole subject from that point of view would serve a useful purpose. Such an inquiry might be suitably brought into being under the ægis of the newly established Board of Control for Inter-Imperial Communication, a board that was first suggested by himself several years ago in the course of a paper read to this Society on "The Administration of Imperial Telegraphs." He felt that if aircraft were to come into satisfactory use for the carriage of mailed matter on anything like a large scale, a really scientific system of word condensation by private codes would require to be turned to account for all correspondence. This would soon show itself to be necessary if only from the standpoint of bulk and weight. It seemed to him that, in addition to the timeliness and value of the paper, Lord Montagu had given them another example of his remarkable foresight in everything that he touched.

General Sir William R. Birdwood, G.C.M.G., K.C.B., K.C.S.I., in proposing a cordial vote of thanks to the author for his valuable paper, said that Lord Montagu had devoted his energies to the development of mechanical transport and aviation both in India and in this country, and the work which he did particularly with regard to the former subject had probably had a great deal to do with the successes which had recently been obtained on the North-West Frontier. When the great war began aviation was in its infancy. It was recog-

nised as a third arm, and that it would take an important part in the war, but nobody had realised that it would take the overwhelming part it did in its later stages. Those in authority were therefore right in proceeding cautiously in regard to the matter. So far as India was concerned they were then very doubtful about the climate, and the author's statement that the climate of India was suitable in every possible way for flying was therefore most interesting. A commencement was made with one small flying squadron, and he might add that when war broke out India unreservedly placed at the disposal of the War Office the whole of her flying resources in both men and material. Again, finance played an important part, because the military budget was strictly limited to 19½ millions, out of which provision had to be made for an army of 75,000 British troops and 150,000 native troops, which did not leave much for aviation. Since the beginning of this war, however, we all had naturally learned in France and on the other battle fronts, and he trusted there would be no doubt as to the course of action to be pursued in the future. He had no inside knowledge of what had occurred in regard to the Afghan invasion, but it looked, from what had appeared in the papers, as if aviation had been the preponderating factor in giving a real check to the Afghan advance, which it would not have been possible to effect so quickly and effectively but for the aeroplane. The moral effect of the aeroplane on the tribes must have been tremendous, and it would probably save India crores of rupees and shorten what might otherwise have been a long war. He hoped that in the future flying would not be dependent for its expansion on the Army; civilians must do the bulk of the work. One difficulty, so far as India was concerned, was that the majority of the population was very poor, so that it was exceedingly doubtful whether many of the inhabitants of the country would be able to afford to go in for flying, whilst those who possessed money might also possess some of that adipose tissue and extra weight which Lord Montagu had told them were naturally such a bar to easy flying. But difficulties existed only in order to be overcome, and he was sure that both Army men and civilians were most grateful to the author for what he had done in that respect.

Sir Charles H. Seely, Bt., in seconding the motion, thought that India was a country particularly suited for aviation, and that it would be of the greatest value in providing more rapid means of communication in that vast peninsula.

The resolution of thanks was then put and carried unanimously, and Lord Montagu briefly acknowledged the compliment.

Sir William Duke, G.C.I.E., K.C.S.I., Chairman, Indian Section Committee, in thanking General Seely for presiding over the meeting, said that his presence in the chair was a sufficient indication of the importance he attached to the subject. Lord Montagu had stated that, in proportion as distances were great, aviation possessed greater advantages, and he thought Lord Montagu would also agree that, in proportion as communications were bad, it possessed greater advantages still. Both those conditions applied to India, and, therefore, India had more to hope from aviation than the rest of the world. Lastly, he thought those present would feel specially grateful to the Chairman for the very happy communication he had made in regard to the prospects of an aerial service from Cairo to Karachi.

RECLAMATION OF PEAT BOGS.

The problem of reclaiming moors and bogs and making them suitable for agriculture, more especially those that are sufficiently high above the adjoining water-courses to be drained by gravitation, is discussed by Th. Claudi Westh in a lecture printed in *Ingeniören.*

The physical condition of such bogs does not make them suitable for agriculture. The peat is light, loose, and very porous, weighing only about 6 lb. per cubic foot when dry. It will absorb twenty times its own weight of water.

The chemical composition of the peat is also unfavourable for agriculture. The peat contains fifteen times more nitrates than ordinary soil, but it altogether lacks the three other essential elements for vegetation, namely, lime, potash, and phosphorus, and without these plants cannot assimilate the nitrates.

The method used at the Knud bog in Jutland is to drain the moor by means of ditches about 80 feet apart, level the surface, and sprinkle with quicklime at the rate of 80 cwts. per acre, leaving it fallow one or two years. The ground is then covered with about 1¼ in. thickness of marl containing about 4 feet of chalk per acre, together with town manure for impregnating the sterile ground. Finally, each acre is treated with 63 lb. of potash and 36 lb. of phosphates. The ground is well harrowed and sown with mixed leguminous seed, principally peas and vetches, also red clover, to prove that the ground has been properly impregnated. After harvesting the ground is again harrowed, treated with potash and phosphates, and sown with grass and clover for pasture. Grass land laid down in 1894 is still used as pasture.

The cost of the reclamation was as follows :—

	£	
Purchase of land	6	per acre.
Reclamation work	10	„
Total cost	16	

For many years the annual profit has been about £1 13*s.* 6*d.* per acre, or about 10 per cent. interest on the capital outlay.

A crop of a ton of good hay per acre has usually

been obtained. Continued cultivation changes tough stringy peat into a loose, dark mould, in which earthworms and moles are able to live.

The reclamation is more difficult where marl is unobtainable, but good results have been obtained in the Knud bog without using marl. In such cases the peat is removed and the conditions are thereby entirely changed, as there is then a firm, permeable subsoil, which can be oxidised when the sour bog-water is drained away, and the mud is mixed with sand or other inert mineral matter.

The ditches should be drained in such a manner that the level of the subsoil water can be raised or lowered at will, according to the needs of the crop.

NOTES ON BOOKS.

Aquatic Microscopy for Beginners. By Dr. Alfred C. Stokes. Fourth Edition, Revised and Enlarged. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. 10*s.* 6*d.* net.

Many a boy must remember his astonishment when the microscope first revealed to him the world of wonder, ugliness, and beauty to be found in a drop of water from a stagnant pond. The present writer has lively recollections of expeditions to the ponds on Hampstead Heath and of long evenings spent in the schoolroom with his eye glued to the eye-piece while he investigated the nature of his catch. It would have been a delight to him to possess such a book as this, for Dr. Stokes gives, in language as simple as is possible in dealing with such a subject, precisely the kind of information that the beginner wants to possess. All the common objects from ponds and ditches are described and most of them are illustrated, so that a smart boy would in a very little time be able to identify and name most of the things on the slip.

The Mica Miner's and Prospector's Guide. By Archibald A. C. Dickson. London: E. & F. N. Spon. 4*s.* 6*d.* net.

The shortness of the mica supply to-day is due, according to Mr. Dickson, not so much to the want of good mica deposits as to the ignorance prevailing with regard to the true nature of the deposits, their depths, forms of occurrence and general characteristics; and his principal object in preparing this little volume is to give information on these and kindred subjects, on which his experience of the management of the well-known Kodarma mines entitles him to speak with authority. He gives an interesting description of eight important mines, with illustrations showing sections of various shoots; and this chapter is followed by others dealing with timbering, drilling, pumping, hoisting and haulage, ventilation, lighting, mining geology, and classes of mica. The book is full of practical information, and should be of service to those engaged in mica-mining, especially in India.

GENERAL NOTES.

Mica as an Insulating Material.—Mica is probably the best available material for armature coil insulation, says *Coal Age.* Manufacturers are now finding in mica the solution of some of the problems of the large-capacity, high-voltage, and high-speed designs of electrical machines demanded in an up-to-date power-plant. Its insulating resistance rises with the temperature, a valuable quality for high-temperature work. Also it is unaffected by temperatures far above those met with in the modern well-ventilated alternator. It is impervious to the static discharges which occur in all high-voltage machines. It is resilient, and it retains its resiliency indefinitely, thus helping to hold the coil tight in its slot. In the form of a "wrapper," that is, pasted on large sheets of specially-treated paper, mica is used on all modern alternating current generators on the straight sides of each armature coil, the working voltage determining the number turns, or thickness of the insulating wall For the lower-voltage machines the mica wrapper is applied as tightly as possible by hand. For the higher-voltage windings, where the insulating wall must be relatively thick, special machines apply the wrapper under heat and pressure, and finish it to a solid, compact wall.

Chinese Antimony.—China at present supplies the greater part of the world's demand for antimony, 62 per cent. of the American imports of the metal in 1916 coming from that country. Most of the ore is mined in the Hunan province, where it occurs practically free from arsenic and contains from 20 to 64 per cent. of antimony. Smelting is done at Changsha, Hankow and Wuchang. Antimony is usually marketed in China in the crude form, containing 65 to 70 per cent. metal. The regulus assays at 98 to 99·8 per cent. The total exports, according to a United States Commercial Report of November 27th, 1918, in 1917 amounted to 15,000 long tons of regulus, 20,000 tons of crude, and 4,000 tons of ore.

Kauri-gum Oil.—The *Engineer* states that a New Zealand company is starting work on the production of oil from a deposit of kauri gum at Redhill, Northern Wairoa. From the crude oil several fractions of oil are produced by further refining. About 15 per cent. is motor spirit, 15 per cent. is a powerful solvent oil, 30 per cent. paint oil, 30 per cent. varnish oils, and the remainder pitch. The oil is the pure product of kauri gum and the oil of the kauri tree. The company has a layer of the oil material 4 feet thick; this is being quarried out with only 1 foot of over-burthen, and the cost of working is said to be merely nominal. A single acre will produce 20,000 gallons, worth, at 26*s.* 6*d.* per gallon, £25,000. The cost of production will not exceed 6*d.* per gallon, all charges on board ship.

Telegrams: "Vacuum, Trowbridge." *Telephone:* 113 Trowbridge.

BURNETT MOTOR TYRES

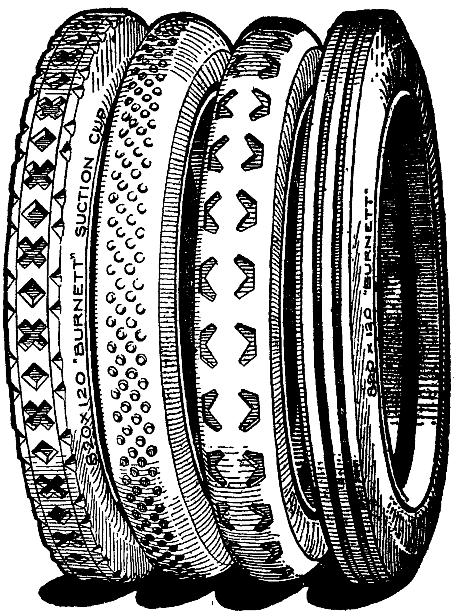
Sole Proprietor:

CUTHBERT BURNETT.

Shetland,
6th May, 1918.

Gentlemen,—
I would thank you to send me your list of tyres, etc. I may say I had one of your tyres some time ago, which gave me every satisfaction.

W. B.



Suction-Cup. Studded. Dauntless. Ribbed.
Patent 14519/10. Reg. No. 642307.

London, N.,
21st June, 1918.

Dear Sirs,—
We return you a tyre, No. 49404, 875 × 105, which may possibly be of interest to you. It has run on the off-side front wheel of a 33-cwt. lorry 7,808 miles without being taken off the rim: it was then punctured; afterwards it ran 1,519 miles, making a total of 9,327 miles. This mileage is considerably more than double the mileage of any other tyre we have had as yet.

POWELL & CO.

COMPLETE PRICE LIST ON APPLICATION TO

The BURNETT Motor Tyre & Rubber Co.

Yerbury Mills, Trowbridge, Wilts.

London Depot - - 71, MORTIMER ST., GREAT PORTLAND ST., W. 1.

CONTRACTORS TO THE BRITISH AND FRENCH WAR OFFICES, Etc.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—July 11, 1919.

No. 3478. JULY 18, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,478. VOL. LXVII.

FRIDAY, JULY 18, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

COUNCIL.

On Monday, the 14th inst., at their first meeting in the new session, the Council elected Sir Henry Trueman Wood chairman for the ensuing year.

Lord Blyth was elected a member of the Council and Vice-President of the Society in place of the late Sir Boverton Redwood, Bt., F.R.S.E.

Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., was elected a member of the Council to fill the vacancy caused by the inability of Mr. G. H. Drummond to serve on the Council.

PROCEEDINGS OF THE SOCIETY.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 21st, 1919; Mr. John Slater, F.R.I.B.A., Member of the Council of the Society, in the chair.

The paper read was—

THE PRINCIPLES OF JAPANESE DESIGN.

By Sir Francis Taylor Piggott, M.A., LL.M.

With great delight I turn from the sombre problems which the war has bequeathed to us to the things of grace and beauty which lie in germ in the word "Art."

This Royal Society of Arts is actively justifying the inclusion of that word in its title by fostering a movement for the promotion of Industrial Art.

It will, I think, be a useful contribution to the work if I lay before the Society some of the principles of Japanese design. To define it accurately, my purpose is to endeavour, with the assistance of this branch of Japanese art, to elucidate the principles of design. I am not going to indulge in comparisons between Eastern and Western art—each has its enthusiastic votaries; nor am I going to discuss the evolution of Japanese art. I take Japanese design for the purpose of my study because I believe it to be the least untrammelled by alien influences, and we are therefore left freer to observe the means which a nation, instinct with a love of beauty, takes to satisfy it. I believe that in that art you do very nearly find the answer to the question which has puzzled the ages—"What is beauty?"

There are many, in other respects excellent people, who are satisfied to give the answer "I know what I like, and that's enough for me." They are comparable to another group of people who "do what they like," and consider that man being born free is entitled to be a law unto himself.

There are others, too, who object to the question being put, because, so they say, it would eliminate what they call "individual taste." Nothing is farther from the intention of the question. The most that it postulates is that beauty in art is not the one thing in the world which is free from the influence of subtle rules. There is not a game—whether it be a trial of strength or of skill—which has not evolved its own rules. They show the best way to win, eliminating mere chance, and are based on a long observation of cause and effect. Why, then, should not that triumph over dulness, which we call "pleasure," in which art is a most potent weapon, also be subject to some rules? More elusive, I grant you; taking a place only among the imponderables of life. Yet still, if the solecism may be forgiven, making their weight felt in the ultimate event: which is the peculiar characteristic of the *imponderabilia.*

Let me bring the matter still closer home, by which I mean to our own home, to the beautifying of which that branch of art which deals with

design is specially dedicated. Are there really no guides—I use the softer word than rules—to the "home beautiful"? I declared that I would avoid comparison—and yet I must permit myself one—between the poor homes of the West and those of Japan. It matters not how humble the dwelling, the trace of beauty, in some form or other, never completely dies; there is always something which makes one understand why houses all alike, apparently, yet may each be invested with some personal touch so as to make each a home to some one. It does not take you long to discover the secret of the all-pervading spirit of art in Japan; the spirit which creates, even in the most uncultivated soul, that disease called Japanostalgia, for which there is no cure while life remains. Every traveller tells the same story: "It is all so restful."

This brings me at once to the first imponderable, the chief virtue in the art of design—Repose: its chief secret, how to attain it.

But we may not, nor do we desire, to recline for ever on the beds of amaranth and moly. Our instincts are for change. We long for clouds to vary the monotony of a sky of changeless blue. And so we come to another imponderable—Variety, apparently the antithesis of Repose. Between these two extremes are an infinity of moods which demand gratification.

First, what are the elements which the designer has at his disposal? These are the principal: Line, by itself, and in its application to Form, or Shape; Space; Colour. Let us examine each of them for a minute.

"Line" has received its tribute of phraseology. Its power has been recognised by the greatest artists, who have sought for the "line of beauty." Pure design has sometimes been called the art of "line for line's sake." The straight line, not always to be condemned, for it has virtues of its own which should guide its use, is only one of a myriad varieties. There is a whole group derived from sections of the cone: the circle, the ellipse, the parabola, the hyperbola, which in its structure (or equation) is the most practical exposition known of the meaning of "infinity." Then there are lines produced by mechanical processes — the "cycloid," which the fly travels upon the wheel as it revolves upon the high road. In scientific language, such a line is the locus of a point on the circumference of a revolving circle moving in a given direction. Of these mechanical lines, which are endless in their variety, perhaps the most wonderful is the "line of greatest strength," which you may see (unless memories of student-days play me false) any day in the Duke of York's Column. That also is the locus of a point travelling in a determined direction. Wonderful, because it demonstrates the inter-relation of different physical qualities, beauty and strength. In the contrary sense, we all have very definite views of the man who follows the "line of least resistance."

Again, there are the natural curves: the most beautiful, the "common catenary," formed by a uniform flexible chain, suspended from two points and hanging freely under the influence of its own weight; the most strange, the "cardioid," which you may see at breakfast any fine morning as the light strikes the inner surface of your tea-cup. Finally, there is that wonderful series of "free lines," which I myself think come nearest to the lines of beauty, produced by the human agency of the hand moving freely at the end of a reticulated arm and body, with the knees as fulcrum. These lines, which are the special character of Japanese art, are uncopiable; it needs some skill even to trace them. You can only reproduce them by resorting to the same method by which they were produced.

The most interesting of all the mysterious questions which art puts to us, is this: In what does the virtue or charm of a line depend? How may the "ugly" be separated from the "beautiful"? Let me suggest this for your consideration. The effect of a line on the senses reaches the brain through the eye. I very much doubt, however, whether the eye takes in a line as a whole. I believe that it travels along a line, and that the sensation produced depends, as in every other kind of travelling, on the incidents it meets by the way. In the case of a line, these incidents are known as its "properties." There is a special branch of mathematics known as "Curve-tracing," in which the properties of a curve are precisely determined by using the familiar symbols x and y to indicate the relation of every point of it to the co-ordinates. The configuration of the whole line is then expressed in terms of an equation.

These are dull mathematical formulæ; and you will wonder whether it is possible for them to have anything to do with beauty, which is the reverse of an exact science. They may, however, help us on our voyage of discovery. For we know this much: that all lines are endowed with properties which earn for them those epithets "beautiful" or "ugly." We know,

too, that the properties of all lines are capable of expression in terms of x and y. It is at least probable, therefore, that the artistic quality of a line is referable in some mysterious way to the relations of x and y in its equation. This seems to be a sound proposition :—that different properties which belong to the same thing, have some relation to one another. So much for Line.

The use of Space as an element of design, sometimes ornamented, but as often blank, is peculiarly Japanese. Of this I shall have something to say in connection with another branch of the subject.

Of the province in design of Colour it is unnecessary for me to say much; but I may remind you that red, blue, green, yellow, are only convenient words to express the different tints and shades of nature's feelings, and that they vary greatly in different countries according to their composition. I draw special attention to the intense crimsons of the lacquer, and the green oxide of copper, which are so largely used in Japanese schemes of decoration.

Colour gives to the artist in design two new materials for his work—Harmony and Contrast. They are another expression of the fundamental qualities I have already dwelt on—Repose and Variety.

But the chief of all the factors by which one or other of these essential qualities is obtained is "Proportion"—the relation of one part of the design to another, as of the ornamented part to the spaces. So important do we hold it to be, that we have raised it to the dignity of a "sense": we talk of the "sense of proportion." It is in the possession of that sense, in the knowledge of the value of proportion, that the Japanese so greatly excel, as I shall hope to demonstrate to you presently on the screen.

I now propose to show you, by example instead of mere precept, how the great designers of Japan availed themselves of these materials and principles, and in so doing I shall emphasise some of the secondary principles of the art as we pass along.

Their work took its highest form in the decoration of the temples; and their principle of work was that time was not of the essence of their contract. No labour was too great, no design too complicated, no time too long, to achieve the end in view. But while they appreciated the value of design to relieve the monotony, they also realised the value of plain surfaces under certain conditions, so long as they were made the vehicle for some special artistic idea. Two things seemed specially able to stand alone, on their own merits—the deep glowing crimson of their lacquer, and the surfaces of wood on which Nature had planned her own schemes of beauty in the tracery of the grain.

But, except in this way, flat surfaces were seldom left unrelieved, and the amount of hand-labour spent upon them was often prodigious. The diaper, in its primitive form no more than an arrangement of crossed and inter-crossed lines, was principally resorted to. Here are some typical examples. In drawing them I have endeavoured to give their effect, which was produced by a triangular-shaped gouge, $\frac{3}{4}$ in. deep, rather than the design in the flat. The effect aimed at was to scatter the light, often heightened by colour —white, red or gold—and produce the design in alternating light and shade, perpetually changing in intensity, as the sunlight passed over it.

In these light-scattering diapers a new factor is introduced—the thickness of the wood or other material bringing with it the characteristics of depth and solidity. Light and shadow, actual and not simulated by artificial shading, became elements of design.

And now the priest stepped in and turned the worldly "pattern" to religious uses. The Buddhist religion availed itself largely of symbols, some of which were, as you shall see, of the simplest. The priest was a master of art and craft; and the curious who only came to admire were reminded of the eternal verities to which these symbols gave formal expression. Thus the diaper came often to be constructed out of the elements of these symbols, of which I show you the fundamental example as well as some more elaborate forms, which have developed in such a way as to produce yet another emblem—the *svastica*, which is very clear in some of the designs.

At this point I am going to lead your thoughts into a rather unexpected channel. Fig. 1, Plate I, is a religious symbol known as the *pakwa*, or the "divining rods," which is an arrangement of lines, either three long ones, or two long and two short. In the more elaborate form the ends of the lines are "returned," as in Fig. 2.

With this element the priestly designers reached one of the many triumphs of their art; they discovered in it an infinite potentiality of design. They took a series of pairs arranged back to back, as in Fig. 3, and locking them together in this fashion they produced this diaper (Fig. 5). Ever seeking new designs, they next arranged these pairs of symbols half back

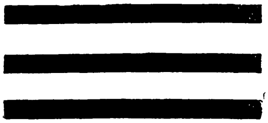


Fig. 1

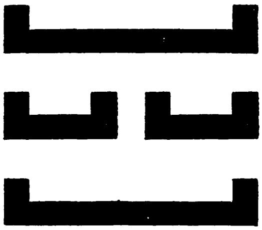


Fig. 2

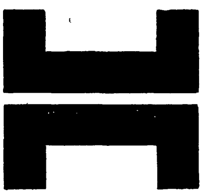


Fig. 3


Fig. 4

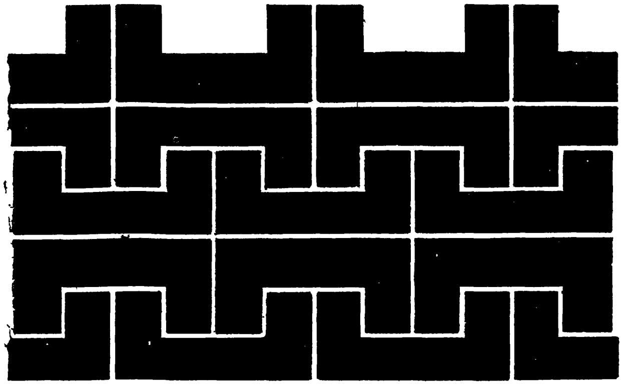


Fig. 5

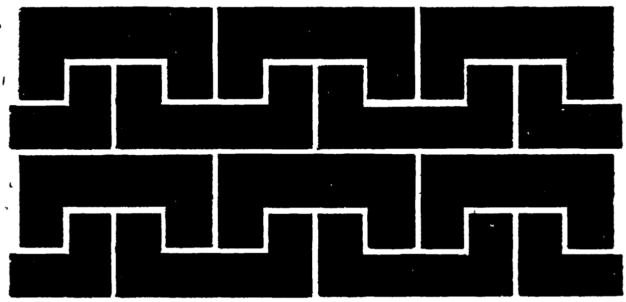


Fig. 6

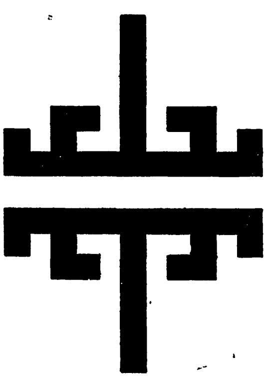


Fig. 7

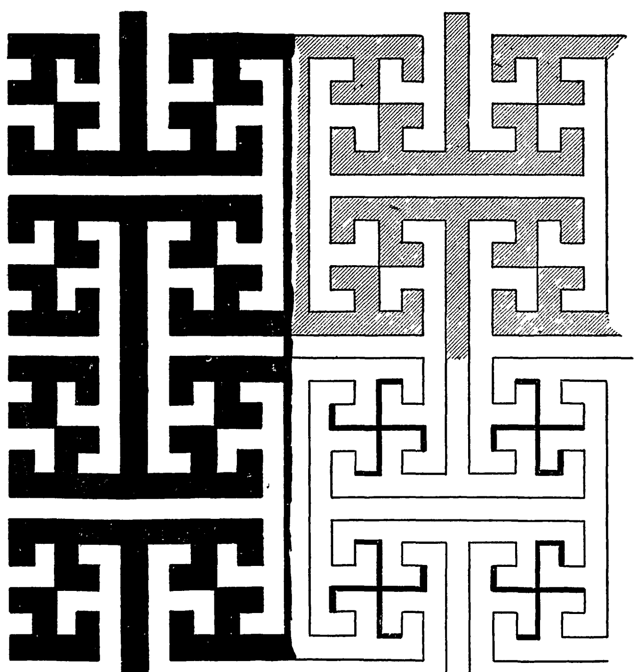


Fig. 8

PLATE I.

FROM SIR FRANCIS PIGGOTT'S "STUDIES IN THE DECORATIVE ART OF JAPAN."

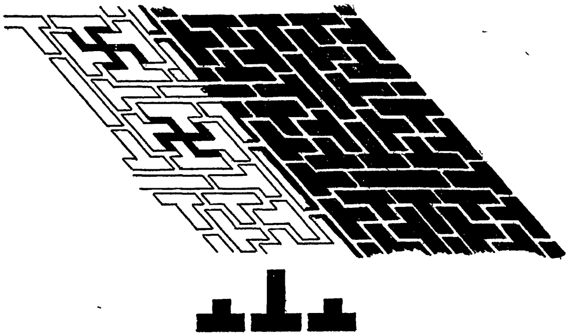


Fig. 9

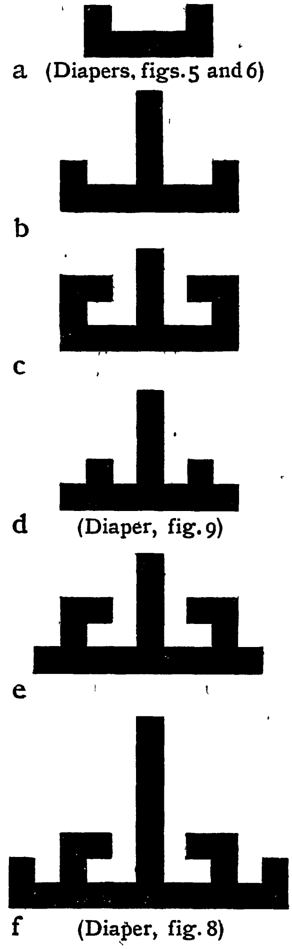


Fig. 10

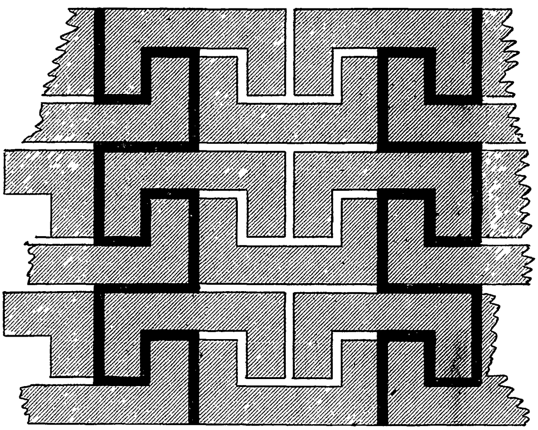


Fig. 11

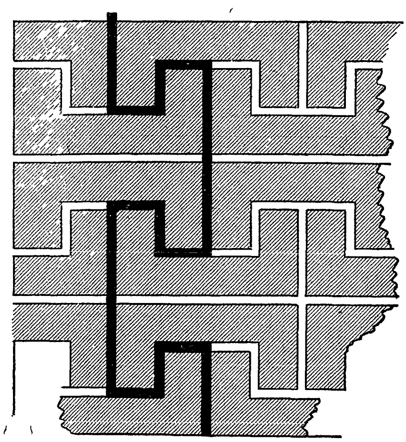


Fig. 12

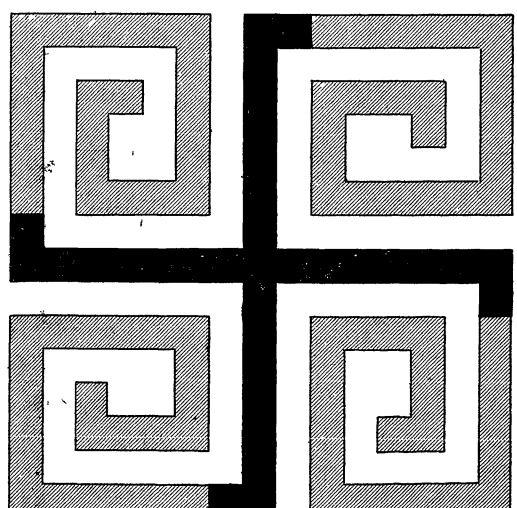


Fig. 13

PLATE II.

FROM SIR FRANCIS PIGGOTT'S "STUDIES IN THE DECORATIVE ART OF JAPAN."

to back, as in Fig. 4, and, again taking a series of them, they produced this diaper (Fig. 6).

Time does not permit me to trace the gradual evolution of this simple design into the elaborate diaper which is familiarly, but very inaccurately, known as *cloisonné* (Fig. 8). This was produced by setting "back to back" pairs of emblems at right angles to one another, and "locking" them. The element is, as you will see, exceedingly complicated, and, if you will bear with me a little, I will show you how it was developed from the simple *pakwa* line. Fig. 10, Plate II, gives the gradual sequence of the elements, the second (*b*) showing a new idea of adding a central limb to the *pakwa* element. Now, if you will bear in mind the principle of construction, imagining them arranged in a series of pairs, back to back, and each pair set at right angles, you perhaps will be able to follow me when I say that this highly intricate diaper was ultimately reached (Fig. 8) with its element; and this very ornamental variety (Fig. 9), in which you will see another decorative factor introduced—Angle or Inclination. My special object in referring to these diapers is to show you the evolution of a very familiar design, which has got its national parentage somewhat mixed.

Taking the elementary "back to back" diaper, and filling in the continuous white space we get Fig. 11; and doing the same with the "half back to back" diaper we get this, Fig. 12, which you will at once say is the "Greek Key" in two of its forms. It is, in reality, the Chinese key; for China was, without doubt, its birthplace. You will say that is a very ingenious way of disturbing preconceived ideas. Why should you draw that line? What evidence have you that they did that in the East? I have abundant evidence, both direct and inferential. The diaper, when it reached the edge of the surface decorated, would be cut too abruptly; so the Chinese devised the border by cutting off a transverse section of the diaper and placing it at right angles: abruptness was got rid of, the eye reaching the top was led off gently in another direction without dispelling the religious ideas which the symbol may be presumed to have generated.

I might devote an hour to this subject; but I must ask you to take this on trust. Every Eastern key-border belongs to some diaper, and the two would be used together. Every symbolic diaper gave in its transverse section a key-border; every true key-border can be developed into a diaper. The Greek "keys" are merely borrowed borders, and when they were evolved in Greece were bastard. The Greeks had no religious symbols, and did not use the diaper in their schemes of design.

Fig. 13 is an interesting design evolved from the *svastika* by prolonging the "returned" ends of its limbs.

Here is another example of a diaper and its developed border, to which I shall refer again presently. But I must not linger, for I have still some distance to travel, and must leave much to your imagination.

From the use of "line for line's sake," the designers, by a process of natural development, turned to "line for form's sake," and, not content with their own imagination, sought inspiration in natural objects, among them the most noticeable and characteristic of the East, from waves and clouds. From a multitude of these designs I have selected these few elementary examples. At this stage native ingenuity led the Japanese to another principle, which is of the utmost importance in design—Appropriateness. Cloud designs would be most effectively used high up in a scheme of decoration; wave designs low down. This was appropriateness in its most simple expression. But the principle was capable of infinite extension. In the temples dedicated to the departed Shoguns, you will find the outer buildings, those which, as it were, represented the splendour of the palace in which they had lived, filled with gorgeous ornament; then, as you pass from building to building to the shrine, the splendour decreases till you come to the tomb itself, which, with its surroundings, was conceived in great and solemn simplicity. The walls of the courtyard are often covered with one of those peaceful wave designs, done on hammered copper plates, symbolical of the soul's last journey across the quiet sea into eternity.

I show you now on the screen a deeply carved panel in which both wave and cloud forms are used.

Nature took a large part in inspiring Japanese design, and, as of course you know, it is specially distinguished by the beauty of its floral forms. Admiration is somewhat promiscuous, and I am anxious to guide your appreciation of it into more legitimate channels.

Floral design divides itself into two main branches. There is, first, the adoption of the natural form of flower or leaf, without intention of representing it. Like the cloud and wave forms, floral form became the inspiration of the artistic form, giving rise to a class of design quite

distinct from pure line ornament—geometrical designs, symbolic diapers, "arabesques," as they are sometimes called—in which there is no representative quality. But there is another class of floral decoration in which there is a much nearer approach to nature, yet which stops short of actual representation, never losing the conventional spirit. This again should form the subject of a full hour's discourse; but I can do no more than indicate, not merely the essential difference between these two forms of decoration, but also the wide chasm which separates floral design from representative art. I have used two terms which I think carry a definite meaning—"natural conventionalism," to indicate designs which are based on floral or other natural forms, and are not simple lines; and "conventional naturalism," where the whole of the flower or other natural form is used, and itself becomes the design, the quality of which depends on suggestion and not on reproduction. Here the flowers are used as, and yet not as, flowers, but as "form for form's sake." This introduces yet another and one of the most essential qualities in design—"Treatment," which distinguishes it from representative art. The natural form, the configuration, of the flower is used, as well as the curvature of its petals; but the high lights and recesses of shade, the "modelling," are omitted as being beyond not merely the purposes of the design, but also of the scope of the material and of the workman's tools.

There is no hard and fast rule against using representative art for decorative purposes; but there is this sound rule: if you do use it, it must be good and not bad representative art.

By way of illustration. There is nothing inherently ridiculous in Berlin wool-work; it becomes ridiculous when it is made the vehicle for *representing* flowers and human beings.

Example being better than precept, I now show you some first-rate examples of the pitch to which the Japanese have brought conventional design, which is one of the most distinctive qualities of their art. The great lesson which they teach is "Suit your design to your material."

But there are other principles at work in these designs to charm the eye, and through the eye, the brain. First, Suggestion. That, I believe to be the secret of the highest design. The artist who wrought this group of chrysanthemums and butterflies, set out with this idea in his head:—I am not going to paint or carve a picture of butterflies flirting over the flowers; I have not the time necessary, nor is there money available, even if my materials enabled me to do it. But I can suggest them to the mind's eye, and, as I think you will agree, with the happiest result.

So in this design. There is no attempt to represent, to give a picture of a pine tree. It is essentially conventional in its treatment, both in its trunk, its branches, and its bundles of spines. But the character of the tree lends its charm to the conception, and behind it is the suggestion, the reminder of the gnarled pine trees which hang over the palace moats in Tokyo. In all artistic suggestion, and probably in half the sensations in life, memory plays a large part; there is a reminder of things once seen, and not willingly forgotten.

I take you back to a diaper which has already been on the screen. The pine needles were clearly the inspiration; and here is its transverse section, or border; and here an independent figure which has sprung out of it.

I must now dwell for a short space on the question of "Proportion" or Balance, which, as I have already intimated, is so important a feature in Japanese design.

You see the lines and the forms, and you are conscious of a feeling of repose; but you ask me, Why "balance"? Why "proportion"? What is in the other scale. Proportion implies a second term. Here there is only space, just blank space. It is in their use of blank spaces, and a mysterious sense of proportion of ornament to space, that the Japanese have found the secret of the hold which the best design has on the mind.

The special feature of this mysterious relation of form and space is that it is never the same. I seem to see in it some such underlying principle as this:—If delight in the beautiful means anything, it must be an intellectual delight, the cause so acting on the brain as to set up those vibrations to which we give the name of "pleasure." We use two other terms in our talk of art—the "commonplace" and the "eccentric." They refer to things in which there is no beauty. In the former we find no pleasure; the latter we reject as irritating. The commonplace sets up few brain vibrations; the eccentric stirs up commotion in the brain, which as often as not creates disgust. These excluded, we are left with the unknown. For "commonplace" connotes a knowledge of the processes on which such effect as there is depends; and the "eccentric" forces itself on the attention, induces a restless seeking for knowledge as to how the

effect is produced, making for brain-weariness, and its final rejection as troublesome or fidgety.

In these forms art appears in its most unbeautiful aspects. Between them lies beauty in its thousand forms, and we find ourselves in the presence of art's mystery, unknown and unknowable, like the greater mystery of life of which it is so large a part. Between mental blank and mental commotion, lies calm, contented, undisturbed repose.

I carry my idea one step further, and illustrate it thus. Where a surface is divided into two equal parts, or in manifest or easily ascertained proportions as of 1 to 3, or 1 to 4, it is commonplace; the mind knows at once how the effect is produced. Where the proportion is very large, as, say, 1 to 100 (as where a design is stuck in a corner and a vast space is left blank), the brain refuses to be troubled with finding it out, rejects it as "out of all proportion," or, as I say, eccentric. But where the process is subtle (as for example 5, 6, 7 or 8 to 11; 8, 9, or 10 to 13; 55 to 97, and so on), the brain, not knowing and resting content with not knowing, the sensation is pleasurable; and the field of it is obviously unlimited.

I take figures merely for the sake of illustrating the idea I am endeavouring to convey. Do not imagine for a moment that I am suggesting that an artist will deliberately say to himself that the proportion of form to space in a design which he has in hand shall be as 7 to 13, or as 23 to 55, or any other abstruse proportion. He will do no more than give his sense of proportion full play. But I do mean to suggest that he will reject the obvious—the centre of the table: or a proportion, such as 3 to 4, with which the eye is familiar; also he will reject the eccentric —sticking an ornament, like a postage stamp, in the corner; and that he will rely for beauty on some unthought-out proportion, the more subtle as it is the more difficult accurately to determine it.

There is one other feature to draw your attention to. The use of the circle in Japanese art to contain the design. The circle is itself a symbol, and when divided into the *yang* and the *yen*, represents completeness and perfection, two things each complementary of the other, producing the perfect whole. From the purely artistic point of view of arrangement of line, the circle is admirably suited for the containing line of floral decoration, because it lends itself to the tangential spring and flow of the lines. This, again, is one of the elementary principles of this form of designing, which it must obey, because it is nature's law—can only be broken when nature itself sets the example.

I am anxious to conclude my paper with some illustrations of Japanese decoration in its practical aspect, and one not very well known: the lattice work of the temples, used for screens or panels, the sides of a temple gateway, or in any place where open work is more suitable than solid wood. The principal feature of the lattices is that their effect depends largely on the sunlight passing through the spaces of the design, so emphasising their form that the eye is as often attracted to them as it is to the surrounding design of the woodwork. The only forms which are familiar to us in the West are the garden trellice made with crossed laths, and the arrangement of semicircular tiles, sometimes called the fish-scale pattern, which is, I believe, to be found in all parts of the world, and in all ages. In Japan it becomes the wave pattern which you have already seen.

The Japanese lattices are formed, like our trellices, of crossed pieces of wood; but they at once give play to fancy by introducing variety in their arrangement, the size of the lozenges is varied, and making the screen more decorative by filling the spaces with an ornament. Then there is the broken or zigzag line, perhaps inspired by lightning, which is a common feature in this class of work, which, when the lines are multiplied, becomes most bewildering. You will also see the position which the space holds in these designs, giving a curious but not uninteresting form.

In the next set of designs we have a new idea altogether. Instead of introducing an ornament into the lozenges the crossed bars have thin slips of wood fastened to the inside, which obliterate the lozenge and produce a new internal space-shape. The idea of introducing these thin slips of wood as an element of the designs having once been originated, it was rapidly developed, and you can see its gradual evolution in the examples on the screen. The characteristic feature of these lattices is that we get a solid complex design composed of four lozenges, as well as the secondary space design. You will notice that when the lozenge is rectangular the inset pieces of wood are uniform, but otherwise they are reversed alternately.

The general effect of this lattice-work is enhanced by the different thicknesses of the wood used in the crossed bars and the ornaments or the inset pieces, which gives play for real shadows, and also for an infinite variety of

design, ranging from the most graceful lightness to solidity.

Here are some other variations. In the last and most complicated the inset slips are of two shapes, cognate but different, and the result is two different space designs.

As in everything else Japanese, there is in these lattices a regular sequence of orderly development, by which the most complicated can be traced back to the simplest.

Finally, here is one of the most elaborate and graceful lattices I have come across.

What I have endeavoured to put before you cannot be dignified as a paper; it is no more than a sheaf of notes, containing suggestions which are, I think, capable of being worked out into a series of orderly propositions, which will make for purity of design, and add to the pleasure of the home. In conclusion, I will show you one more design, on the outside and the inside of a gold lacquer box, which seems to me to be the embodiment of all the principles which I have endeavoured to put before you.

It is a gnarled old plum tree, such as one sees in Japanese gardens in late winter; in its conception it is true to nature, preserving the twists of branch and twig: and it is true to art, as the designer has not attempted to go beyond the limit which his materials set to his work. You will, I think, feel the sense of proportion which controls the design, and how wonderfully it has been adapted—I should say, has adapted itself—to the circular containing line. And there is one touch of nature's inspiration which I would have you notice. The fallen blossoms lie thickest near the parent trunk. That is how the breeze drops them when their flower-duty is fulfilled.

DISCUSSION.

The Chairman (Mr. John Slater, F.R.I.B.A.), in opening the discussion, said the author had given a very interesting and illuminating survey of the principles which underlay Japanese art. There could be no doubt that Sir Francis was quite correct in saying that in any art two of the principal virtues were repose and variety. He (the Chairman) did not think anyone could have examined any article of Japanese art without being struck by the evidence it showed of an utter absence of all haste and hurry. The minutest attention was given to detail. Every feather of a bird, every hair of an animal, and every fold of a garment seemed to have been the subject of special loving study and leisurely execution, and yet the result was never laboured. He had sometimes thought that there was a considerable analogy between the art of Japan and the art of the old monkish illustrators of missals and other mediæval manuscripts, in which were found the same absence of hurry, the same attention to detail, the same play of fancy, and the same love of colour as in Japanese art, although, of course, the technique and the scale of the two were very different. He might be speaking from insufficient knowledge, but it seemed to him rather curious that the Japanese artist, with all his feeling for line, all his perfect draughtsmanship, did not appear to have been much addicted to reproducing the beautiful curves of the undraped human figure. He let himself go in voluminous drapery and in landscape, and that voluminous drapery gave him a wonderful opportunity for the display of colour. He (the Chairman) thought he had seen it stated somewhere that, however daring the scheme of colour in a Japanese picture, no discords would ever be found. One of the lessons to be learnt from Japanese art was that the design should always be suited to the material in which one was working. That could never be too much insisted upon. Especially was it true in architecture, for nothing could be more disturbing than to see a material being tortured into shapes for which it was not fitted. The neglect of this lesson was, he thought, the cause of the great decay in art which was found in the later flamboyant and rococo architecture. It seemed as if the artist was always essaying a *tour de force*, and saying, "See how extremely clever I am with this material!" That was unrestful and unharmonious, and he did not think one would ever find a Japanese artist attempting a *tour de force*. Another lesson which might be learned was that it was always better to decorate one's construction than to construct one's decoration. He had been much interested in what the author had said about that mysterious symbol, the *fylfote*, or *svastika*. It was found all over the world—among the ancient civilisations, in Scandinavia, something very like it in Cornwall, in Germany, among the Etruscans, in India, and in Japan. In fact, so widespread was it that it seemed hardly possible it could have had one origin, and if the author was right in saying that the *svastika* was developed from a certain arrangement of lines with returned ends it might very well have been evolved separately. What the meaning of the mysterious symbol was he confessed he did not know. A great number of different opinions had been given about it. One man had told him that every person who wrote about it was either a crank or a faddist. Sometimes the *svastika* seemed to be considered as a representation of the sun, sometimes of water, and it was just possible from the derivation of the word that it might have been a token of good luck.

Mr. A. J. Koop (Victoria and Albert Museum) thought everyone would agree that Japanese ornament was peculiarly *sui generis.* In the course of a fairly long experience he had never met with a single imitation, whether slavish or fairly distant, of Japanese art which did not lack that "something"—that *caractère*, as the French would put it, which only the native artist himself was capable of showing. The feeling of true ornament was undoubtedly inherent in the Japanese race as a whole—more so, he thought, than in any other modern race—though a parallel was found in the nations of the past, especially in those of ancient Hellas. He would make even so bold as to say that, with the exception of a certain amount of bazaar rubbish and a group of art products which were confessedly based on European influence—or, at any rate, non-native influence—the charge of possessing not the slightest artistic interest or value was one which could not, he thought, be justly levelled against anything Japanese whatever. In describing the diapers, which so very obviously formed the origin of the so-called key pattern of the Greek fret or Chinese fret, whichever one chose to call it, Sir Francis had ascribed the origin to what were known as the *pakwa*. The *pakwa* were eight variations of a group of three lines or broken lines. One might either have a group composed of three long lines or one of one long line and two broken lines, and that would make up the number of eight. Those were the *pakwa*, which was the Chinese for eight divinatory signs. The author had taken two out of those three lines, and if there was any real religious Buddhistic significance in that origin of the diaper, why should only two have been chosen out of three, because surely the significance of the *pakwa* was in the trinity of the lines? He would go even further than that. He could not see why, if one were going to derive a pattern from two straight lines, it was necessary to go to a certain group of symbols of which one consisted of three straight lines. Surely straight lines or elongated blocks existed—he did not say in nature, but in art—apart from those particular symbols, and he did not see why it was necessary to go to the *pakwa* in ascribing the origin of the fret. Moreover, he had never seen the long or the short lines of the actual *pakwa* with any returns on the end. The addition of those returns seemed to him thoroughly out of keeping with the *pakwa* signs themselves, and that was his reason for somewhat doubting the Buddhistic origin of those diapers. The author had also quoted the Japanese love for the circle in forming the outline of a piece of ornament. There was one very important group of Japanese ornaments, and that was the heraldic badges. It would be found that any heraldic badge as properly drawn would fit exactly, that was to say, with proper balance, into a circle and into no other form—he would not say into no other form, because some would fit in a square, but everybody knew that a square would fit perfectly into a circle, so there one had the connection. It would be found that every single Japanese badge fitted, conformably with all rules of art, into a circle. A second group of circles was the Japanese sword-guards. The guard of the Japanese sword was an object easily removable, and was almost without exception a flat disk, and usually of metal. That flat disk in its earliest form was generally understood to have been actually completely circular. As ornament appeared in it, pierced ornament at first, it got more and more elaborate throughout the ages—indeed during the 250 years ending about 1870 the ornament applied to Japanese art in general became more and more elaborate; but he was principally concerned with the shape of the things. It would be found that the circular shape well-nigh entirely dropped out of use. He had examined thousands of Japanese sword-guards, and, except in very early pieces, he had rarely found the true circle. The question would be asked: "How could we describe this as a group where the circle came in?" The point was that the most common shape for those sword-guards was the oval, but it was an oval that very frequently indeed was so nearly a circle that until one came actually to measure the major and the minor axes of the oval one imagined that it really was a circle, and indeed to all intents and purposes, for the purpose of filling up the space with decoration, it was practically a circle.

Mr. Arthur Wilcock expressed his appreciation of the exposition of the lattice and diaper, which was quite new to him. His chief interest in Japanese art had been from the organic side. He should express the lattice and the diaper as being the inorganic side. Japanese art had appealed to him chiefly by its wonderful spontaneity of drawing, and the deftness of touch. The Japanese seemed to be inimitable; they stood quite alone in their expression of nature, and as drawers of birds he did not think they could be bettered.

Mr. A. F. Kendrick (Victoria and Albert Museum) remarked that when the author had stated at the beginning of his paper that he did not propose to indulge in comparisons between the art of the East and the art of the West, many in the audience wondered how such an acknowledged master of his subject would be able to get through his paper without touching on that in any point, and, of course, he had failed, and the audience were delighted that he had failed. When the author had been giving his most informing and most valuable analysis of the various diaper patterns, he had pointed out how the fret which had been commonly known so long as the Greek fret must share, at any rate, its origin with a Chinese source. There were other features in which the

author had brought in that comparison, to the meeting's great delight, and he (the speaker) did venture to hope that the members of the Society might yet have an opportunity of hearing the author on the important and even vital problem of the relation between the art of the Far East and of the West. Twenty-five years ago or less no student of Western art would have thought of worrying about the art of the Far East until he had reached, say, the seventeenth century; one felt that previously the Far East had ploughed its own lonely furrow. But one's ideas had been rather disturbed. People had learned to recognise in mediæval art some subtle influence which seemed to come from far away, and then when they looked for concrete examples which might have served as models, they were found in mediæval church treasuries; there were also other things dug up in Egypt which were obviously of mediæval Chinese origin, which had been under the soil of Egypt for a good many centuries. There were many features which had to be explained, and one felt that in searching out the various influences on mediæval art one must travel gradually farther and farther eastward. There was a large field before investigators into the subject—for instance, the excavations in the Gobi desert, and they would have to find out whether that great cataclysm many centuries ago, which was supposed to have put the final touch on the history of those regions, really was so final as people had been led to imagine, and whether again some of the objects in those silted-up caves and temple chambers were not a little later than some supposed. Investigators, as he had said, had a large field before them, and people were looking to them to cover it and tell them the results, and when they did so he felt quite sure that several chapters in the history of mediæval art would require to be rewritten.

Mr. A. D. Howell Smith (Victoria and Albert Museum) remarked that he was in no position to criticise the author's interesting account of the evolution of some of the Japanese diapers, but he had been very much struck by what the author had said about the evolution of the Greek key, which he derived from China; and certain difficulties had arisen in his mind with regard to the historical movements that brought about the transfer of that pattern from China to Greece, because, so far as he had been able to study the history of China and her relations with Western Asia, and with Europe through Western Asia, he had found that the movement was all the other way. Continuous relations between China and Western Asia dated from the second century B.C., when the great Chinese statesman Chang Ch'ien went into Bactria. He was held in captivity by the Huns for a good many years, but ultimately he had been able to open up diplomatic relations between China and the Indo-Scythians and the Greek kingdom of Sogdiana; and it was known that he imported the vine from Bactria into China, and that a considerable Greek influence did get through Bactria and through other parts of Western Asia, which had absorbed Greek culture and Greek influences, into China. He did not remember when the Greek key began, but it was pretty early, and the Chinese key pattern of the Chou dynasty, for example, which came to an end in 256 B.C., was very different. It did not involve the *svastica* ornament at all. He understood the author to say that the *svastica* had grown naturally out of the evolution of the fret diaper, but yet the *svastica* was found to be extremely widespread and generally associated with some form of religious symbolism. He found a difficulty in understanding how the *svastica*, which pervaded the religions of India, notably Buddhism, came from the Chinese key fret. If the *svastica* which was an evolution of the Chinese key fret had a different origin from that of the Indian *svastica*, it only showed how similar ornaments might grow up quite independently without showing any historical continuity between the two.

Mr. W. G. Raffé said the paper had suggested to him a very interesting subject which he was at present studying, namely, the mathematics of beauty. With regard to the derivation of form from one part of the world to the other, if one went into the historical point of Japanese art it would be found that it came from China somewhere about the fifth century; and, again, it would be found, if one cared to attack the psychological end of art as well as the physical end—that was, an inductive as well as a deductive method of search—that Japanese art, being very much more psychological, was more connected with religion than Western art was. Buddhism, having come through China to Japan from the northern parts of India, some origin could easily be found in that part of the world in a similar way to that in which Professor Whitehead had traced the origin of our numerals. Professor Whitehead had traced those through the old Arabic to the Sanscrit, and he (the speaker) ventured to think it would be found that the religious symbolism had taken a similar journey both East and West at the same time. It was well known that the early Greek philosophers before Plato had a great amount of thought in their philosophy which was very similar to Buddhistic philosophy. That, in conjunction with the mathematical basis, was extremely interesting, because those designers, even in their practical everyday work of setting up designs, must have had a remarkable degree of accuracy in the setting out of the pattern to get it so accurate. That same thing was found in the Greek mouldings in the British Museum. He had measured them with modern engineering

tools, and the precision was really marvellous when one came to consider the fact that they had no steel rules or micrometers to work with. With regard to symbols and their later derivation into uses not so well known, that was a common fate of symbols. There was the symbol of the cross, which, as a matter of fact, existed long before the Christian religion. It existed in the old Egyptian books. The fish had been adopted by the second and third century Christians in Rome, and had been at that time a symbol of the Holy Ghost. That symbol, too, had been known to the priests of at least the third century B.C.

SIR FRANCIS PIGGOTT, in reply, said it was too late in the afternoon for him to take up the points which had been thrown out in the discussion. He was very conscious indeed of Mr. Koop's criticism that the *pàkwa* were a series of eight arrangements of straight lines. Mr. Koop had asked him if he was conversant with a *pakwa* with returned lines. He would have to go back twenty-five years to answer the question. He could only say that he thought he had seen it. He did not think he had invented it, and therefore he must have seen it. The *svastica* had the return, and he thought his original idea was that the notion of the returned lines of a *pakwa* had sprung from the *svastica*, but he could not be sure. With regard to the *svastica*, however, he would like to point out that he did not say that the temple diapers were its origin, but it was a fact that when the most complicated of them were taken we did arrive at the *svastica*.

A vote of thanks was accorded to the author for his paper.

MANGROVE BARK RESOURCES OF THE PHILIPPINES.

Mindoro is one of the larger islands of the Philippine group. It is a province by itself and comprises an area of 3,983 square miles. It is distant from Manila a little more than 100 miles, or twelve hours by steamer. Along the shores of this island province are considerably more than 30,000 acres of mangrove swamps, with large trees in practically virgin growth, conservatively estimated to yield 50,000 tons of bark, readily convertible into approximately 17,000 tons of cutch. Why this advantageously situated growth of mangrove should have remained untouched for so long is hard to understand. In a report to his Government on the mangrove bark resources of the Philippines, the United States Commercial Agent in the Islands calls special attention to the Mindoro resources in mangrove, but they are not the only ones in the Archipelago. Altogether there are twenty-one species of mangrove in the swamps of the Philippines—two more than are found in Borneo. These are to be found in the swamps in Bataan or Manila Bay; at the mouth of the Danao River in Occidental Negros; in the municipality of Barotac Nuevo in the Province of Iloilo; and stretches along the island of Palawan, as well as the growths for forty-five miles along the shores of Mindanao. The possible cutch production of these swamps is tremendous. Plenty of cheap labour is available, and there is no duty to be paid on the extract entering the United States. The tannin content of the barks is stated to run from 12 to 35 per cent., and to be on average quite as satisfactory as that of the Borneo mangroves.

At the chemical laboratory in the Bureau of Science, Manila, a cutch was made by leaching from the finely-ground bark in cold water, the solution being reduced to dryness in a vacuum. The resulting cutch was dry, solid, brown in colour, and the fracture was brilliant—almost metallic. It was easily and completely soluble in water.

Analysis of barks from Mindoro show tannin content ranging from 9·6 to 28·2 per cent. Those from Mindanao show content from 8·8 to 27·2 per cent. The highest amount of tannin found in samples of Borneo bark was 32 per cent.

While many of these swamps are large enough to be commercially attractive, those of Mindoro seem at present to offer the best inducements. They are directly controlled by the Bureau of Forestry and may be worked under licence. The timber growths of the Philippines are carefully conserved, so that they could not be worked for bark alone, but the demand for piles, poles and firewood is so great that the stripped timber could be readily and profitably marketed. Another basis upon which to work would be to buy bark from independent firewood cutters, who would welcome such a market. Still another possible method would be in conjunction with one of the large lumber concerns. One of these is operating in Mindanao, and, at the date of the report, was not using the bark at all.

STRAW HAT INDUSTRY IN ANTUNG.

In the Antung district, during the four warm months of the year, inexpensive native-made straw hats are worn by men and children of all classes. These hats are made of pliable straw, probably more than 90 per cent. of the total output being of coarse, unbleached straw braid, and retailing at about 1*s*. 3*d*. each. The remainder are of finer and bleached straw braid, and retail for the equivalent of from 4*s*. to 12*s*. each.

With the exception of a very limited number of Japanese-made straw hats, which are sold almost exclusively to Japanese residents, all of the hats used in the Antung district are of Chinese manufacture, approximately 50 per cent. of the straw hats sold there being of local manufacture. Practically all of the dyed hats, which are worn exclusively by children, are brought to Antung from Tientsin, and other cities in North China.

According to a report by the United States Consul

at Antung, the straw-hat industry there was begun in the spring of 1917; it is confined to Antung city, and is very modest in its size and equipment. It comprises five firms, to whose workshops the term "factory" can hardly be applied. The three largest of these employ approximately ten men each, and their equipment of machinery consists of three sewing machines; each of the smaller workshops employs four men, and has one sewing machine as equipment. In July, 1917, the daily output was 1,900 hats. The raw materials used are practically all of domestic origin. Straw braid plaited from wheat straw is brought from Shantung Province; the glue is of local manufacture; and the imitation leather for sweat bands, and the ribbons for hat-bands are brought from Shanghai and Tientsin.

PATCHOULI PRODUCTION IN THE STRAITS SETTLEMENTS.

Patchouli is both a wild and a cultivated crop in the Malay Peninsula. The following data concerning it were furnished to the United States Consul at Penang by the Director of Agriculture for the Federated Malay States.

Patchouli (*Pogostemon patchouli*) is a soft-leaved herb from 2 ft. to 3ft. high, much branched, with square stems, emitting when rubbed the characteristic smell of patchouli. The Chinese, who chiefly cultivate this plant in Malaya, often plant it on newly cleared ground among the fallen logs. Here, slightly shaded, it grows very rapidly and well. Where it is regularly cultivated, it is planted in properly prepared beds.

The best method of propagation is by cuttings of young shoots. These are cut about 3 in. long, care being taken to cut just below a joint. The cuttings are placed in nursery beds, well watered and shaded. In three weeks to a month they will have rooted, and can be removed to the permanent beds, where they should be shaded until thoroughly established. The plant grows well in open sun, but it will also stand a little shade, and may be grown as a catch crop in young rubber or coconut clearings. The cuttings may be planted at distances of about 2 ft.

The first crop can be cut about six months after planting, and afterwards twice a year. In Perak it is usual to take only three crops and then replant. The leaves when cut out may be dried in the sun, but it is better to dry them in the shade, spreading them out in a cool and airy shed. When quite dry (about one week) they may be packed in bales. One picul (133⅓ lb.) of the leaf, dried just as it is cut, yields from 24 to 30 oz. of essential oil, and a sample free from the heavier stalks yields about double that amount. Thirty-six pounds of green leaves produce 10 lb. of patchouli. One-twentieth of an acre planted gave 449 lb. of green stuff, and after ten days it had dried to 106 lb., which on picking over gave 69 lb. good leaf and 37 lb. refuse. The dried leaf is exported from the Federated Malay States principally to Marseilles and New York. The exports of patchouli leaves from Penang to the United States during 1917 totalled 79,979 lb., valued at £2,450. Local exporters of native products are in a position to handle a much larger volume of trade in this commodity if a demand arose.

PRODUCTION OF DIVI-DIVI IN DOMINICAN REPUBLIC.

Divi-divi is the commercial name for the astringent pods of a leguminous shrub indigenous to the Dominican Republic. The plant is between twenty and thirty feet in height and bears white flowers. The fruit of this shrub is a bean, averaging two inches in length, one inch in width, and about one-eighth of an inch in thickness. It contains about 30 per cent. of a tannic acid, used in the manufacture of leather. The bean ripens and falls to the ground from November to April. If it rains while the beans are on the ground they are ruined. Large quantities are lost in this manner, as November and December are rainy months in the Republic of Dominica.

Whole families of the poorer people devote their entire time to gathering divi-divi beans and bringing them to market. It is difficult to state the average yield per shrub; some produce as many as seventy pounds or more, and others of the same age yield only half that quantity.

Almost all of the divi-divi shrubs in the Puerto Plata district, writes the United States Consul at Puerto Plata, are to be found in the arid lands of the Province of Monte Cristi. They are not cultivated, but grow wild over vast sections of the province. The town of Monte Cristi, on the north coast near the Haitain border, is the centre of the industry, and is the port from which most of the product is exported. Divi-divi is usually packed for export in jute sacks, weighing from 110 to 125 lb. gross. It was formerly shipped to some extent in bulk in sailing vessels, but this mode of shipment has been discontinued as it was not found practicable.

The value of this product is determined by its quality and appearance; large, plump and ruddy beans are in good demand, while small, black and broken beans are unsaleable. The annual exports of divi-divi from Monte Cristi formerly exceeded 2,000,000 lb., but of late years they have fallen below these figures. The decline in the output is attributed to a species of orchid, which lives on the shrubs. This parasite reduces the production and often kills the plant. Nothing has been done to eliminate this pest, although it has spread at an alarming rate, so that there is hardly a shrub which is not infested with it.

Prior to the war divi-divi was exported to Hamburg almost exclusively; in the past few years, however, it has found a ready market in New York. The prices were formerly fixed in Hamburg at from 9 to 12 marks per 50 kilos (roughly £8 to £11 per ton), but last year the price was from £10 to £11 per ton (2,000 lb.) f.o.b. New York.

OBITUARY.

Sir Percy Sanderson, K.C.M.G.—Sir Percy Sanderson, of Caversham, Reading, died on July 11th, at the age of seventy-seven. Born in London, he was educated at Eton and Addiscombe. In 1859 he received a commission in the Royal Madras Artillery, and five years later he exchanged to the Royal Horse Artillery. In 1865 he became A.D.C. to Sir William Denison, then Governor of Madras, and in the following year he was appointed a third-class Commissary of Ordnance. In 1868 he acted as A.D.C. to Lord Napier, Governor of Madras, and in the same year he became first-class Commissary of Ordnance at Fort St. George. After retiring on half-pay in 1870, he was Consul at Galatz in 1876, Consul-General for Rumania and Commissioner for the Navigation of the Danube in 1882, Acting Chargé d'Affaires at Bukarest from 1881–86, and Consul-General at New York from 1894–1907. He was made a C.M.G. in 1886, and a K.C.M.G. in 1899.

On his retirement from the Consular Service, Sir Percy Sanderson settled at Caversham, and took an active part in the charitable and public business of Reading and Caversham. He was a J.P. for Oxfordshire and for Reading, was for some time a member of the Oxfordshire County Council (until Caversham was incorporated into Reading); and he was also President of the Veterans' Association, and Chairman of the Committee of Management of the Berkshire Hospital.

Sir Percy Sanderson was elected a member of the Society in 1908, and attended the meetings from time to time. He was a brother of Lord Sanderson, G.C.B., who was Chairman of the Council from 1911–13.

Josiah Harding, M.Inst.C.E.—Information has been received of the death of Mr. Josiah Harding, of Antofagasta, Chile, which took place on March 12th, as he was on his way to Santa Cruz.

He was born at Hawkes Bay, New Zealand, in 1847, and after being educated at Christchurch and Crewe he proceeded to Antofagasta in 1875, where he was engaged in constructing the Antofagasta railway. He was engineer to most of the Chilian railways, and the great line from Arica in Chile to La Paz in Bolivia was constructed on his plans. He patented several inventions, the principal being a brake which is used largely on South American railways.

Mr. Harding was elected a member of the Royal Society of Arts in 1898. The *Journal* of June 20th contained an article by him on "Alcohol and Cold," in which he gave his personal experience as a life-long abstainer on the value of temperance in enabling men to withstand extremely cold climates.

GENERAL NOTES.

American Trade Competition.—The efforts American business men are making to capture Danish trade are referred to in the *Board of Trade Journal*. It is said that in the Baltic countries, with a highly disadvantageous exchange, or practically no currency, Americans are taking up mortgages on the best available securities—chiefly real property—and opening a dollar credit, with the result that practically only dollar-priced goods will be saleable in the lands in question. The Americans have been disposing of their surplus war stocks to countries depleted of every kind of manufactured goods at prices higher than could be obtained under normal conditions. The unpreparedness of other nations who suffered more than America in the war renders this policy comparatively easy of fulfilment. The American banker supplies the money and makes the banking profit, whilst the American shipowner contemplates reaping the transport profits on forwarding the goods. By furnishing the depleted Scandinavian markets with their most urgent needs, the Americans hope, having obtained the commercial connections and organised banking and transport facilities, to find a market for an intensive manufacturing activity in the future. Although the Americans have secured an initial advantage, the United Kingdom, it is satisfactory to learn, "should have no very difficult task to meet American competition in many branches."

Substitute for Jute.—The shortage of jute brought about by lack of shipping space during the war, and the greater need for that material due to war conditions, felt by the Brazilian sacking manufacturers, compelled the latter to look about for some home-grown fibrous substance that could be used as a substitute for jute. Already before the war experiments had been made with *Arimina* and the *Conhamo Braziliensis Perini* with a view to make the industry independent of imports from the East Indies. But the results, according to the *Oesterreichische Chemiker-Zeitung*, were not satisfactory, and the scheme was dropped. Later experiments, however, with aloe fibre (*Fourcroya gigantea*) have shown that to be an excellent substitute for jute, the spun and woven goods being a hundred per cent. stronger than those manufactured from the Indian product. As the plant grows abundantly in Brazil, it can be obtained at considerably lower prices than jute.

A Colloidal Silicate.—In the course of the work of the Department of Scientific and Industrial Research, attention has been called to a certain colloidal silicate, apparently not hitherto in use, which may possibly prove to be of commercial value, especially in the textile industry. It is notified that a limited number of small samples of this substance may be obtained on application to the Department of Scientific and Industrial Research, 15, Great George Street, Westminster, S.W. (1)

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—July 18, 1919.

No. 3479. JULY 25, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,479. VOL. LXVII.

FRIDAY, JULY 25, 1919

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

SIR GEORGE BIRDWOOD MEMORIAL FUND.

The above fund will be closed on August 31st next. The amount already promised is £662 12*s.* 7*d.* In accordance with the terms of the appeal, published in the *Journal* of November 8th, 1918, the money will be devoted to the endowment of an annual "George Birdwood Lecture" in connection with the Indian Section of the Royal Society of Arts. The names of the subscribers are as follows:—

H.H. the Aga Khan, G.C.S.I., G.C.I.E.; A. Yusuf Ali, C.B.E.; Sir Charles Carrick Allom; A. S. M. Anik; Sir Arundel T. Arundel, K.C.S.I.; the Lord Askwith, K.C.B., K.C.; S. Athim.

D. N. Bahadurji; Sir Athelstane Baines, C.S.I.; G. Percival Baker; the Nawab of Banganapalle; H.H. the Maharaja Gaekwar of Baroda, G.C.S.I.; Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.; T. J. Bennett, C.I.E., M.P.; Sir M. M. Bhownaggree, K.C.I.E.; Ardeshir Jamsetjee Bilimoria; the Lord Blyth; General Booth (Salvation Army); Sir Shapoorji Broacha; F. H. Brown; the Hon. Maharaja Dhiraj of Burdwan, K.C.S.I., K.C.I.E.

Shapurjee N. Chandabhoy; Sir Narayan Ganesh Chandavarkar; Surgeon-General Sir Richard Havelock Charles, G.C.V.O.; Sir Valentine Chirol; Sir Dugald Clerk, K.B.E., F.R.S.; T. E. Colcutt, F.R.I.B.A.; Messrs. Cox and Edwards; Sir William Crookes, O.M., F.R.S.; Laurence Currie; the Right Hon. Earl Curzon of Kedleston, K.G., G.C.S.I., G.C.I.E.

F. W. Dickinson; S. Digby, C.I.E.; Captain W. Pollard Digby; Sir William Duke, G.C.I.E., K.C.S.I.

Peter MacIntyre Evans, M.A.

W. Foster, C.I.E.; Alice, Lady Fowler; B. S. Framjee; Admiral the Hon. Sir Edmund R. Fremantle, G.C.B., C.M.G.; Sir Bartle Frere, Bt.

The Worshipful Company of Girdlers; Colonel A. Gleadowe-Newcomen, C.I.E.: Sir George A. Grierson, K.C.I.E.; Sir K. G. Gupta, K.C.S.I.

The Right Hon. Lord George Hamilton, G.C.S.I.; the Right Hon. Lord Hardinge of Penshurst, K.G., G.C.B., G.C.S.I., G.C.M.G., G.C.I.E.; the Lord Harris, G.C.S.I., G.C.I.E., C.B.; Harold Hartley; G. Booth Heming; the Hon. Sir Claude H. A. Hill, K.C.S.I., C.I.E.; Sir Edward H. Holden, Bt.; F. A. Holman.

The Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E.; the Right Hon. Lord Islington, G.C.M.G., D.S.O.; Sir John Jardine, Bt., K.C.I.E.; Merwanjee D. M. Jeejeebhoy; Sir Cowasjee Jehangir, Bt.

H.H. the Maharaja of Kolhapur, G.C.S.I., G.C.I.E., G.C.V.O.

The Lord Lamington, G.C.M.G., G.C.I.E.; the Lord Leverhulme; Lady Liberty; Major-General Beresford Lovett, C.B., C.S.I.; Sir Charles J. Lyall, K.C.S.I., C.I.E.

Sir Charles C. McLeod; T. McMorran; W. J. Maitland, C.I.E.; J. H. Malcolm; the Medici Society; G. K. Menzies, M.A.; the Right Hon. E. S. Montagu, M.P., Secretary of State for India; Sir R. N. Mookerjee, K.C.I.E.

The National Bank of India; J. C. Nicholson; Messrs. Nixon, Forrest and Co.

John O'Connell.

The Hon. Richard Clere Parsons; Sir Prabashankar D. Pattani, K.C.I.E.; L. Penny.

The Right Hon. Lord Reay, K.T., G.C.S.I., G.C.I.E.; Colonel J. H. Rivett-Carnac, C.I.E.; L. Robertson; B. T. Rose; G. M. Ryan.

Shapurji Saklatvala; the Lord Sanderson, G.C.B., K.C.M.G.; Mrs. S. D. Sassoon; R. D. Sethna; G. F. Sheppard; John Slater, F.R.I.B.A.; Miss Annie A. Smith; Sir James R. Dunlop Smith, K.C.S.I., K.C.V.O., C.I.E.; H. C. Sotheran; Alan A. Campbell Swinton, F.R.S.; Miss Ella Sykes; Brigadier-General Sir Percy M. Sykes, K.C.I.E., C.M.G.

Sir Dorabji J. Tata; Lady Ratan Tata; Taw Sein Ko, C.I.E.; Lieutenant-Colonel Sir Richard Carnac Temple, Bt., C.B., C.I.E.; Carmichael Thomas; Messrs. Times, Dharwar and Co.; H. J. Tozer.

Mrs. Patrick Villiers-Stuart; Dr. J. A. Voelcker.

Sir Dinshaw E. Wacha; N. N. Wadia, C.I.E.; Henry Wagner; A. F. Wallace; Colonel Herbert Walters; Alfred Warner; Sir Frank Warner, K.B.E.; Willingdon Dinner (balance); Sir James Wilson, K.C.S.I.; Sir Arthur N. Wollaston,

K.C.I.E.; Sir H. Trueman Wood, M.A.; Miss Martin Wood.

Colonel C. E. Yate, C.S.I., C.M.G., M.P.

T. J. Bennett, *Hon. Treasurer*.
S. Digby, *Hon. Secretary*.

Royal Society of Arts,
John Street, Adelphi, W.C.(2)
July 24th, 1919.

REPORT ON THE "OWEN JONES" PRIZES.

Following the precedents of 1917 and 1918 the Council this year, with the kind assistance of the Director of the Victoria and Albert Museum, arranged for a competition of students of Schools of Art in accordance with the terms of the Owen Jones Trust. Notices were issued in November last stating that six prizes would be offered under the usual conditions. Each prize consists of a bound copy of Owen Jones's "Leading Principles in Composition of Ornament" and a Bronze Medal. The subjects of competition this year were:—

Architectural Decoration: Including Stained Glass, Mosaic for Walls and Floors, Plasterwork in relief and incised, Inlaid Marble and Stones, Lettering for Memorials.

Woodwork and Cabinet Work: Including Carving in Wood, Ivory and Bone, Inlay, Chairs, Chests, Cabinets.

Textiles*: Including Tapestries, Carpets and Rugs, Moquettes, Floor-coverings (*e.g.* Linoleums and Floor-cloths).

The date for the receipt of competing designs was fixed for June 28th, 1919, and arrangements were made for their inspection at the Victoria and Albert Museum.

The following judges were appointed by the Council to consider the designs submitted: Mr. J. H. Dearle (Messrs. Morris & Co.), Mr. Ambrose Heal, Mr. A. F. Kendrick (Department of Textiles, Victoria and Albert Museum), Mr. John Slater, F.R.I.B.A., and Sir Frank Warner, K.B.E.

Fifty† designs were sent in from nine Schools of Art by thirty-one students, as compared with thirty-seven designs submitted from nine schools by thirty-one students in 1918, and one hundred and twenty designs submitted from twenty-two schools by seventy-three students in 1917. The smallness of the entries is no doubt due in part to the fact that the numbers of students in Schools of Art are still much depleted in consequence of the war. Unfortunately the quality of the work is as disappointing as the quantity, and the judges only felt themselves able to award two out of the six prizes offered.

The only entries received under the heading "Architectural Decoration" were five designs for mosaics. These were commonplace, and were not considered to be deserving of commendation.

With regard to the designs for Linoleums, these all appeared to be based on tile patterns, and in the opinion of the judges it is undesirable to imitate in one medium the characteristics of another which is essentially different from the first in its principal qualities.

The awards of the judges are as follows:—

Prizes.

George Willott, School of Art, Macclesfield.
Design for a Tapestry Frieze.

Mary Bulley, L.C.C. Putney School of Art, Oxford Road, Putney, S.W.
Design for an Axminster Carpet in Eight Colours.

Commended.

George Smith, School of Art, Macclesfield.
Design for a Tapestry Hanging.

Maxey Zaimin, Technical School of Art, Arundel Street, Sheffield.
Design for a Carved and Inlaid Cabinet.

C. T. Bale, Municipal Technical Science and Art School, Barnstaple.
Design for Wood Panels and Wood Carving for a Ship's Cabin.

N. M. Nelder, School of Art, Tiverton.
Wood Carving of Centre Portion of a Cornice for a Notice Board. (Commended for the execution but not for the design.)

Arrangements have been made for the exhibition to the public of the competing designs. They are now and will remain on view until August 30th, from 10 a.m. to 6 p.m. in the Class Room, Department of Textiles (First Floor), Victoria and Albert Museum, South Kensington, S.W.

In announcing the awards the Council desire to add an expression of their thanks to the judges for the trouble they have devoted to the work and for the promptitude with which the awards have been made.

They wish also to state their appreciation of the assistance rendered to the Society by the Director of the Victoria and Albert Museum and his staff.

The Council feel that it is desirable to attract greater attention to this competition in the Schools of Art, and they have therefore decided to offer in each of the next three years an additional prize of £20 for the best design submitted, irrespective of class.

The full conditions and arrangements for the Competition in 1920 will be announced later.

* Other classes of textiles will be prescribed in 1920 and 1921.

† Of these seven were not eligible under the classes prescribed for 1919.

SOME OF THE FACTORS IN THE INDUSTRIAL DEVELOPMENT OF THE HAWAIIAN ISLANDS.

By J. N. S. Williams, M.I.Mech.E.

This article is offered in response to a suggestion that, as the records of the Society do not include any paper on Hawaii, or on the resources of the islands, such a contribution might be welcomed by the Council.

The eleventh edition of the *Encyclopædia Britannica* contains a very concise and readable article on Hawaii, which gives excellent and reliable information on the history, geography, ethnography, industries, and political status of this interesting group of islands. In the minds of most people they will always be associated with the death of Captain James Cook, R.N., who was the first to make known to the world the discovery, early in the year 1778, of this the greatest of Polynesian archipelagoes, and who was slain by the natives at Kealakekua Bay, Island of Hawaii, in February, 1779, just about one year after his discovery of the group.

It is intended to describe in this paper some of the factors to which is due the remarkable progress of the principal industries of the Territory; but before entering on the subject matter, a very brief description of the physical characteristics of these islands may not be out of place.

The archipelago known as the Hawaiian (or Sandwich) Islands is situated in the North Pacific Ocean, between 154° and 179° west longitude, and between the parallels 19° and 29° north latitude. The islands lie in a chain which stretches for several hundred miles from Ocean Island at the north-western extremity to the Island of Hawaii at the south-eastern end of the group.

Having a sub-tropical situation in the North Pacific Ocean, with a clear stretch of thousands of miles of water in every direction, the climate is moderately warm, the average temperature of earth and water being about 72° F., while the extremes of temperature of the air range from 54° F. in the early morning at certain seasons of the year at sea level, to 90° F. in the shade at midday at certain other seasons, the mean temperature the year round being between 73° and 75° F.

The north-east trade winds prevail during a considerable portion of the time, and the rainfall on the windward, or that side of the islands facing the trade winds, is heavy, in a few places being upwards of 400 in. per annum. From 20 to 30 in. of rain per annum falls in certain cultivated districts, which, however, require to be irrigated to produce crops of sugar cane; while in other districts, where the rainfall is from 70 to 150 in. per annum, sugar cane can be grown, and is grown, without irrigation.

These islands are very mountainous, and are supposed to have been formed by submarine volcanic action, but there are other theories as to the origin of this land.

On the Island of Hawaii, at the south-eastern extremity of the group, there are two volcanic craters, one of which, situated at an elevation of some 4,500 ft. above the sea, on the slopes of Mauna Loa, is nearly always in action, and can easily be reached by automobile over a good road, while the other, situated on the top of Mauna Loa, about 13,000 ft. above the sea, is very difficult of access, and is active at rather long intervals.

Slight earthquakes are frequent, but these are very rarely severe enough to cause damage. Hurricanes are not frequent, and when they do occur they come from the south or south-west, and are usually accompanied by very heavy tropical rains.

The tops of the highest mountains rise to over 13,000 ft. above sea level, while the mountain ranges forming the backbones of the islands are upwards of 4,000 ft. in height, with isolated peaks of a greater height occurring at intervals; on the highest mountains snow falls in great quantity during the winter months, the fall sometimes extending down to the timber line, about 6,000 ft. above the sea.

There are five principal islands and three small ones, which comprise the habitable districts, the other islands in this archipelago being mere islets or reefs, which are seldom visited.

The large islands—Kauai, Oahu, Molokai, Maui, and Hawaii—are separated from each other by sea channels varying from 20 to 70 miles in width. Communication between the islands and the mainland of the United States, Canada, Australia, and the Orient is maintained by several lines of modern steamships carrying passengers, mails, and freight, and by an excellent ocean cable and wireless service, the latter using both the Marconi and Poulsen systems.

The capital city of the territory is Honolulu, situated on the island of Oahu, and distant from San Francisco, California, some 2,100 miles, or about six days' voyage on vessels available at the present time.

The industries of these islands are the manufacture of raw sugar and the production of canned pineapples, rice, coffee, sisal, and beef. Cattle are produced in some quantity, and an attempt has been made to grow tobacco and cotton, but so far with little success. There are numerous other industries dependent on the main enterprises, such as ironworks, for the construction of machinery and execution of repairs; fertiliser works, for the manufacture of fertilisers required in the various agricultural operations; wood-working establishments, rice and coffee-cleaning mills, inter-island steamer lines, railroads on certain of the islands, and the usual wholesale and retail commercial establishments, banks, hotels, theatres, newspapers, and, to be brief, all the commercial and social machinery demanded by modern conditions of life.

The total area of the inhabited islands is about 6,450 square miles, which, however, is composed in large part of arid mountain tops and slopes, lava beds, scoria fields, and rocky waste lands on the lower levels.

The total area is divided roughly as follows:—

Arable and pasture lands .	43	per cent.
Forest lands	25	,,
Waste lands, useless for any purpose	32	,,
	100	,,

The cultivated lands range from sea level up to an elevation of about 3,000 ft. above the sea. Sugar cane flourishes up to 2,000 ft. above the sea, and it can be grown in certain favoured districts at a higher elevation; rice grows well at sea level and a little above; pineapples do well at an elevation of about 700 to 1,200 ft.; and coffee is seen at from 1,200 to 2,000 feet.

The cattle ranges are situated at all elevations where good pasturage can be found, but the principal cattle runs are situated on lands between 1,500 and 3,000 ft. above the sea.

The forest lands are now almost entirely included in Government and private forest reserves situated at elevations up to about 6,000 ft., and are largely fenced to keep out cattle and other animals, for the purpose of preserving the trees and the forest undergrowth. These are important factors in conserving and distributing the rainfall, it having been realised by years of experience in this direction that the denudation of the forest area has been followed by an alteration for the worse in the distribution of the rainfall, which, while as copious as ever it was, is not as regularly distributed as formerly in those districts in which the watersheds have lost their forest covers.

The rocky waste lands at the present time are hideous deserts, some of them miles in extent, with little to relieve the gloomy monotony of the black lava fields, the barren red mud flows, and the contorted crags which are the chief features of the landscape in these desolate regions. Indications are that at some distant day a forest growth may establish itself, or be established by forestry methods on part of this waste area; but whatever may be done, these deserts will be useless for human purposes for a very long period of time.

The population of this Territory is composed of many nationalities; the results of the census taken in 1910 are given below:—

Hawaiians and part Hawaiians. .	38,485
Caucasians	44,050
Japanese	70,674
Chinese.	21,694
Filipinos and others	17,006
	191,909

At the present time (1918) the total population exceeds 250,000 in number, not including service men in the United States army and navy stationed here, said to be some 10,000. There is a large number of British-born persons living in this Territory who are American citizens, but the number is practically stationary; the registered voters of British birth in 1904 numbered 542, in 1910 they numbered 554. Since the Great War broke out in 1914 the British population has been considerably reduced by the departure of a number of the younger men who have joined the British and Colonial forces and are serving their country wherever required.

The Territory of Hawaii is an outpost of the United States in the North Pacific Ocean, and as such is of very great strategic value; Pearl Harbour, a land-locked body of water near Honolulu, is an important naval station, and Honolulu itself is so favourably situated with reference to the lanes of traffic crossing the North Pacific, that it has become a port of call for many lines of steamers engaged in trans-Pacific trade, which touch for fuel and water.

Industrial Development.

The principal industry in the Hawaiian Islands at the present time is the manufacture of raw cane sugar, which is produced in such quantities as to have some influence on the

world's sugar market. But it was not always so; in early days the industry had a hard struggle for existence. The first cane planters and sugar manufacturers had many and serious difficulties to overcome, the principal ones being the scarcity of suitable labour for cultivating and harvesting the cane fields, and the uncertainty as to prices and market.

The second most important industry in this territory is the production of canned pineapples. This industry dates back a comparatively few years; the first pineapples in any quantity were exported in the year 1903, some 1893 cases of about 50 lb. each, while for the year 1916 the export reached the number of 2,609,483 cases, having a value of about $6,500,000. Due credit must be accorded to the pioneers in this field, but they had no such obstacles to overcome as had the early sugar men, and it is literally true that but for the establishment of the sugar industry in these islands on a permanent and profitable basis, all other enterprises would either not have been started, or would have been carried on in a very small way.

The first sugar made in these islands was produced early in the last century. In the year 1820 about 150 tons are said to have been made, and presumably consumed in the country, since no mention is made of any export at that time. The first officially reported export of sugar took place in the year 1837, to the amount of two tons, possibly sold to whaling ships, which for many years, and as recently as 1880, made the Hawaiian Islands a place for re-fitting, provisioning, and for disposing of their catch of oil and bone.

In the year 1860 the export of sugar was 572 tons (2,000 lb.), and in the year 1870 this figure had increased to 9,392 tons.*

The isolated position of the Hawaiian Islands in the early days made communication with the outside world slow and very irregular. As the sugar industry progressed it became very evident to the planters and their business associates that a steady and permanent market was an essential condition if the progress already made was to continue. Early in the sixties, San Francisco, already a port of great importance, was attracting much attention, and naturally the eyes of those in the islands, vitally interested in their own business, were turned towards California and the United States as not only the nearest, but the best market for their sugars and other agricultural products.

* All tons mentioned in this paper are of 2,000 lb., that being the United States of America standard ton.

Reciprocal Relations with the United States.

About the year 1866 the Government of Hawaii took preliminary steps to open negotiations with the Government of the United States, looking towards the establishment of reciprocal relations between the two countries, and after some years of discussion, during which much opposition was developed in certain quarters of the latter country, a treaty of reciprocity was entered into between the two high contracting parties, which became effective in September 1876.

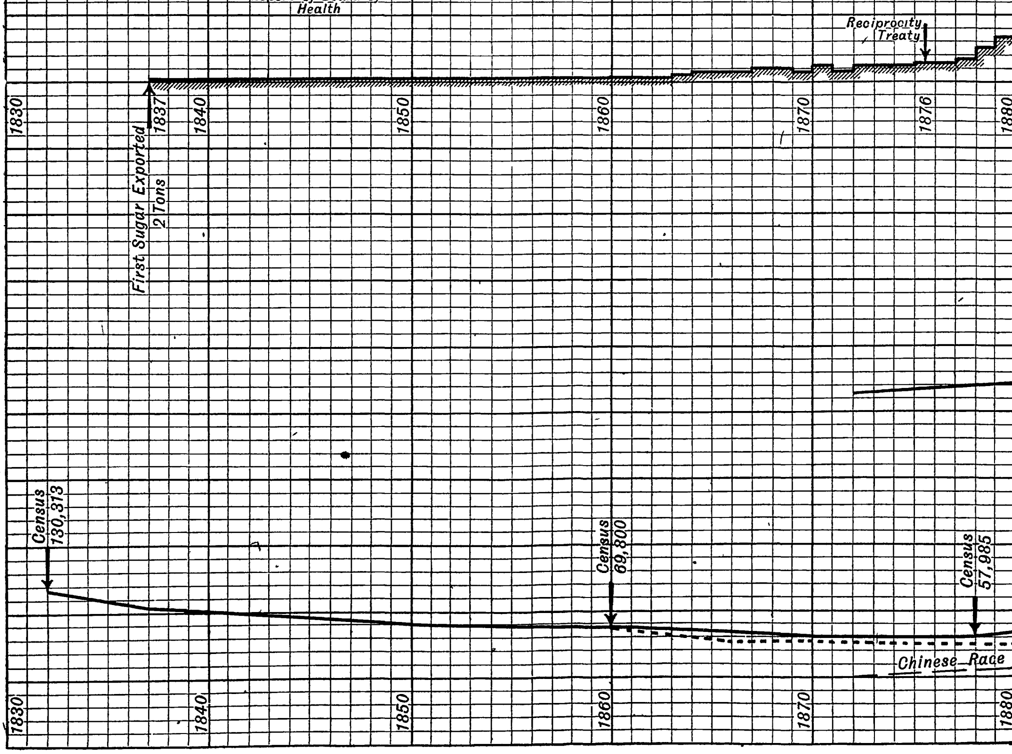
The principal objects sought to be accomplished by this agreement were the encouragement and increase of trade, and the creating of more intimate commercial relations, which would greatly strengthen American interests. By the terms of this convention the leading agricultural products of Hawaii, including raw sugar, rice, etc., were admitted free of duty into all ports of the United States, and nearly all the agricultural products and manufactures of the latter were admitted free into Hawaii for a term of seven years certain, and, after that period had elapsed, until twelve months' notice of termination of the agreement had been given to the other by either of the signatory parties.

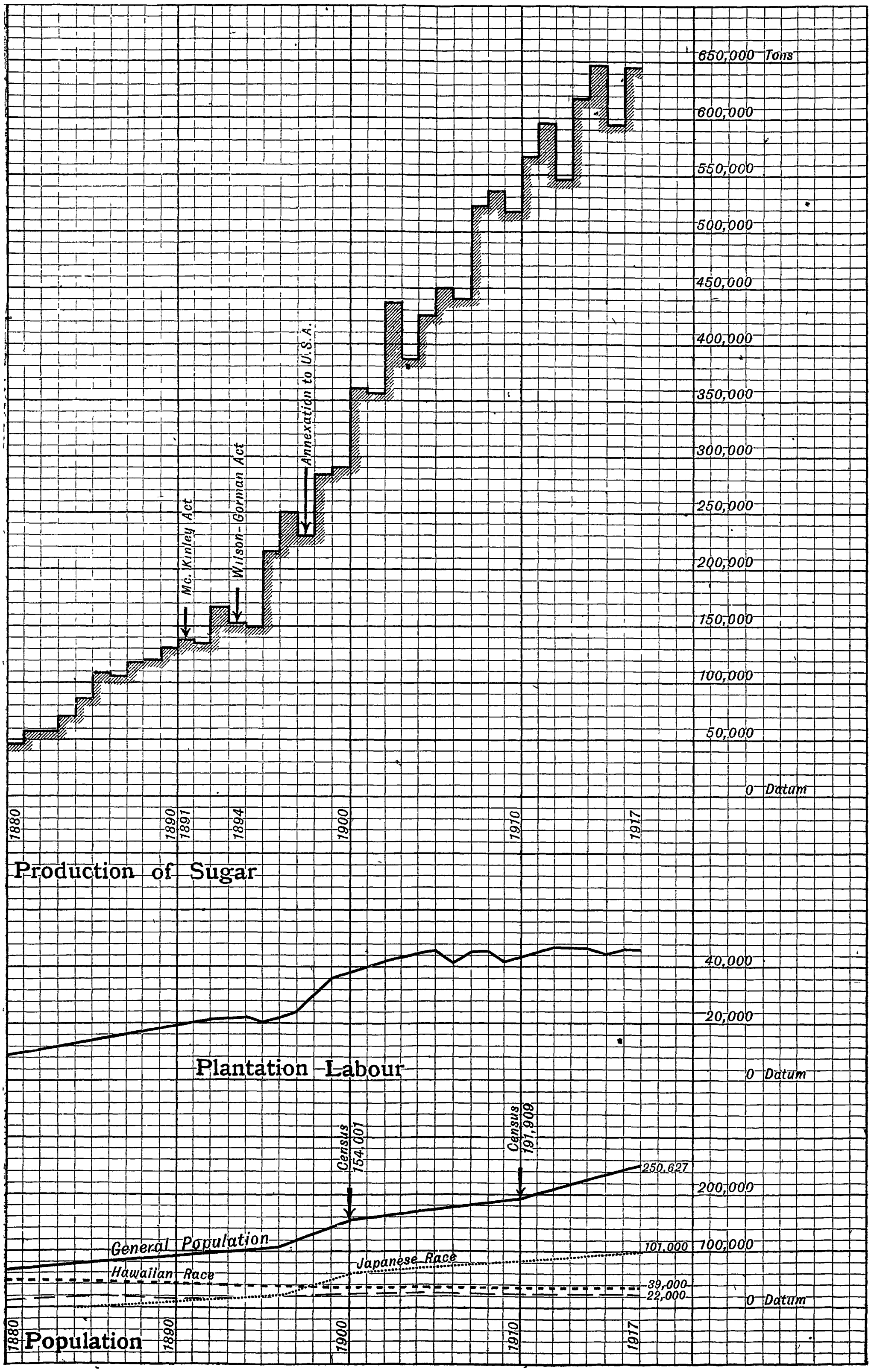
The sugar planters of Hawaii were in this way assured of market and price for their product for at least eight years to come, and the stimulus thus given to the sugar industry was very apparent within a short time, as is very clearly shown on the chart, in the increased output, which rose from about 12,500 tons in 1875 to about 57,000 tons in 1882.

To obtain the necessary supply of suitable labour to operate the sugar plantations was in those days, as it is now, the most serious problem with which the Hawaiian planters had, and have, to grapple.

In the year 1870 the native Hawaiian race furnished practically the entire labour force required on the plantations at that time, but the rapid decrease of the native people (see chart for population) showed only too clearly that, as the sugar industry expanded, the native population could not be depended upon to furnish the requisite labour, and the isolated position of the islands has always rendered difficult and expensive the task of recruiting and transporting suitable labour in sufficient number from abroad; it was not without reason therefore, in view of the declining labour supply, that in 1882 the planters became anxious as to the future of the industry.

Year		Total Population	Tons of Sugar made or exported (Tons 2000 lbs. each)	Number of Acres harvested	Number of Plantation Labourers	
1832	Census	130,313				
1836	Census	108,579				
1853	Census	73,138				
1860	Census	69,800	572			
61			1281			
62			1503			
63			2646			
64			5207			
65			7659			
66	Census	69,959	8865			
67			8564			
68			9106			
69			9151			
1870			9392			
71			10,880			
72	Census	56,987	8498		4772	Census
73			11,565			
74			12,283			
75			12,540			
76			13,036			
77			12,788			
78	Census	57,985	19,215		7871	Census
79			24,510			
1880			31,792			
81			46,895			
82			57,088	23,000 estimated	8277	Data obtained from H.S.P.A. records and Thrum's Annual
83			57,053			
84	Census	80,578	71,327			
85			85,695			
86			108,112		14,518	
87			106,362			
88			117,944		15,957	
89			121,083			
1890	Census	89,800	129,899		18,959	
91			137,492			
92			131,308		20,536	
93			165,411			
94			153,342		21,294	
95			147,627	47,399	20,120	
96	Census	109,020	221,828	53,572	23,780	
97			251,126	53,883	24,653	
98			229,414	55,235	28,579	
'99			282,807	60,309	35,987	
1900	Census	154,001	289,544	63,816		
01			360,008	78,618	39,587	
02			355,611	80,954	42,242	
03			437,991	93,350		
04			367,475	91,798	44,230	
05			426,428	95,444	44,949	
06			429,213	91,798	41,303	
07			440,017	99,716	44,575	
08			521,123	101,380	44,789	
09			535,156	106,127	41,748	
1910	Census	191,909	517,090	110,247	42,846	
11			566,821	112,796	44,268	
12			595,258	113,866	46,930	
13			546,798	113,548	45,875	
14			617,038	114,458	46,213	
15			646,445	117,078	44,299	
16			593,483	114,269	46,117	
17	Report of Board of Health	250,627	644,574	120,251	46,695	




650,000 Tons
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0 Datum
Annexation to U.S.A.
Wilson-Gorman Act
Mc. Kinley Act
1880
1890
1891
1894
1900
1910
1917
Production of Sugar
40,000
20,000
0 Datum
Plantation Labour
Census 154,001
Census 191,909
250,627
200,000
General Population
101,000
100,000
Japanese Race
Hawaiian Race
39,000
22,000
0 Datum
1880
Population
1890
1900
1910
1917

Co-operation.

To meet the situation a meeting of many of the Hawaiian planters was held early in 1882, and a plan for entering into an association was laid before this meeting in a speech from which the following is a quotation:—

"It is high time that men who desire the prosperity of this country, or who care to secure or protect whatever they may have at stake here, should meet and consult together, and devise and adopt measures which will subserve the interests of the entire community.

"There is wonderful power in organised and combined action. Fifty men of intelligence and good repute in a community may exert themselves for public objects with little or no effect so long as they act separately; but acting in concert and mutual understanding the results they can accomplish are beyond comparison with their individual efforts.

"There is the entire labour problem upon us, and it requires united and concentrated effort to solve it . . . I am convinced that while the friendly aid and co-operation of the Government is essential, this matter of getting labourers will never be attended to effectually until the planters attend to it themselves . . . Other pressing reasons for forming this association will occur to all of you. Our methods of planting and cultivation of cane and the manufacture of sugar are susceptible of immense improvement. Sugar producers and buyers, I hope, can be brought nearer together . . . I will not pretend to suggest to you all the objects which might be accomplished by such an association as is now proposed, nor the methods by which they can be effected. That is what we have met here to deliberate upon."

The men who listened to this speech, of which the above is a very small part, were the men who in 1882 held the destinies of the then kingdom of Hawaii in the hollows of their hands; they were men of unusual business ability, wide vision, and great executive and administrative power, as is revealed by the results which flowed from the action then taken.

The Planters' Labour and Supply Company was formed forthwith under a charter granted by the Minister of the Interior of the Hawaiian Islands by and with the consent of the King and his Privy Council, "for the purpose of adopting such measures to obtain suitable labour for the Hawaiian Islands as may from time to time seem best to such Association, and of securing such improvement in the cultivation of sugar cane and manufacture of sugar as may seem to be desirable."

The organisation of this body was on the same lines as most corporations, a board of trustees or directors being elected by the members or stockholders, the board appointing a president, a treasurer, and a secretary, the whole forming the governing body of the Corporation. The president appointed committees from among the membership to look into and report upon the various subjects of interest connected with the industry, such as labour supply, cultivation of irrigated and non-irrigated lands, manufacture of sugar, forestry, etc., and the reports were read and discussed at the annual meetings. The expenses of the Association were defrayed by the annual membership fees, and by an assessment per ton of sugar made by the manufacturing members of the Association, the amount of which was determined on the basis of a species of budget made up each year by the treasurer, and presented to the board of trustees for consideration and action.

The immediate problem in hand for the newly organised Association was the procuring of a sufficient labour supply to meet the pressing wants of the growing industry. This was successfully accomplished, as the records disclose that between 1882 and 1890 the labourers employed on the plantations had increased from a little more than 8,000, with a sugar output of about 57,000 tons, in the year 1882, to about 18,000, with a sugar output of about 130,000 tons, in 1890, and the labour supply was steadily augmented until in the year 1917 the number of labourers employed in the industry was approximately 46,000, producing an output of sugar of nearly 650,000 tons.

Labourers were obtained from all over the world. Germany, Norway and Sweden, Spain, Portugal and Italy, China, Japan and Korea, Russia, Polynesia and the Philippine Islands, have all been represented in the cane fields of Hawaii, but at the present time a very large proportion of the field labour is Japanese, who are industrious, thrifty, energetic and ambitious. Following these in numbers come the Filipinos, and then the Portuguese, Chinese, and others.

It will be noticed that in 1882 the output of sugar amounted to about 7 tons per annum per man employed on the plantations; in 1890 this production remained about the same; in 1900 this ratio had increased to about 9½ tons per annum per man employed; and in 1917 the output of sugar per annum per man employed on the plantations had about doubled that of 1882, since in 1917 each man employed produced about 14 tons of sugar.

This was due to the efficient carrying out by the Association of the charge laid upon it at the inception of the enterprise of "securing such improvement in the cultivation of sugar-cane and in manufacture of sugar as may seem to be desirable."

The chart exhibits the annual increase in the output of sugar, and the regularity of the increment from the date of the Reciprocity Treaty (1876) to 1891, when the United States statute known as the McKinley Act became effective, is clearly shown. The effect of the McKinley Act, which removed the duty on raw sugars entering the United States, was to deprive the Hawaiian sugar planters of the benefits of the Reciprocity Treaty by reducing the price obtained in the American market for their sugars by the amount of the duty so removed. The following extract from a publication in the year 1891 well reflects the feeling which prevailed amongst planters in Hawaii at that time:—

"The advantages and benefits formerly enjoyed by us through our treaty relations with the United States no longer exist since the law abolishing the tariff on sugars imported into the United States has gone into effect. The price of sugar has fallen, and the industry in many cases is unremunerative.

"We find ourselves in open competition with all of the sugar-producing countries of the world, handicapped with expensive labour and supplies."

The Wilson-Gorman Act, which restored the duty on sugars entering the United States, became effective in the latter part of 1894, but the Hawaiian planters had some years of free sugar and consequent low prices to meet; this, however, was not an unmixed evil, for while the prices of sugar were ruinously low, there was a strong feeling among those interested that adverse legislation in the United States could not last against the opposition which had been aroused; consequently, while straining every resource to keep in good cultivation the full area in cane, they were compelled to put into effect every possible economy in cultivation, harvesting, and manufacture of sugar so as to hold their own in anticipation of the re-imposition of duties on sugars entering the United States, and the lesson in economy thus learned has never been forgotten. It is, however, certain that had the Hawaiian sugar planters had to meet world competition in an open American market for a few years longer, wide-spread disaster in Hawaii would have resulted.

Following the reimposition of the sugar tariff as noted above, the production of sugar in the islands steadily and rapidly increased to the year 1898, in which annexation of the Hawaiian Islands to the United States of America took place; and then, all question of market and price having been settled, the planters bent all their energies and accumulated surpluses to the increase of the cultivated area and output of sugar with the results herein related.

During the later years of the period under description more sugar was obtained per man per annum, and per acre per crop, than was the case in the earlier years, and to explain this it is necessary to hark back to the year 1895, in which year the Planters' Labour and Supply Company held its fourteenth annual meeting in November.

The president announced to the Association on this occasion that, after considerable study, discussion and arrangement, the trustees of the Association had decided to establish at its own expense an experiment station, fully equipped with laboratories, etc., and with a well-qualified analytical chemist and agriculturist in charge of the station and its activities. The president also stated that the Company had outgrown the sphere of operations limited by its charter provisions, and outlined a scheme for the disincorporation of the original Association, and for re-organising under a new name, with increased powers and carefully revised and improved by-laws.

The following day the members voted in favour of the proposed change, and thus the Hawaiian Sugar Planters' Association came into being, and immediately started on that career of investigation, experiment and report, which has made its name famous throughout the cane sugar world.

Some years were occupied by the experiment station staff in studying the soils and agricultural conditions of the islands as a whole, and much very valuable information was gathered and printed for circulation amongst the members of the Association.

Because of the time to mature a crop of sugar cane in this country being from eighteen months to two years, extensive experiments on the different kinds of fertilisers and various methods of fertilising—that is, applying the fertiliser—took years to complete. Similarly, a great deal of time was spent in experimenting on different varieties of cane with the object of improving the qualities of such canes as to sugar content, yield per acre, and power of reproduction from the roots after the first harvesting (commonly known as rattooning),

so that it was not until well after the year 1900 that results began to be visible in the increased production of cane and sugar per acre of land cultivated and harvested.

Shortly after the opening of the twentieth century, all the factories represented in the Hawaiian Sugar Planters' Association sent in weekly reports of factory results, and at the annual meeting of the Association in the year 1904 the idea was advanced of instituting the compilation of a weekly comparative statement of milling and sugar-making results, to be drawn up by the experiment station staff, and distributed weekly to each of the members, so that each one could see what all the others were accomplishing.

After some opposition and considerable discussion it was brought out that such comparisons would lead to increased interest and competition amongst those responsible for factory operations which could not but be beneficial to the industry, not so much in exhibiting what the best equipped factory could accomplish, but in revealing conditions in the smaller and less well equipped places, the improvement of which would raise the general average of factory work throughout the Territory to a higher degree of efficiency.

This plan was within a year put into effect with the most satisfactory results, the average extraction by the crushing machinery of sugar (as juice) from that in the cane being steadily increased from about 92 per cent. in the year 1900 to over 97 per cent. in the year 1917.

Economies were also effected in the use of labour by the introduction of numerous labour-saving devices.

So it will be seen that while the quality of cane and the yield of cane per acre were being improved by scientific fertilising and cultural methods, the yield of sugar from the increased quantity and better average quality of the cane was being increased by parallel improvements in the various factories, and thus the increased production of sugar per acre and per man per annum is accounted for.

In the year 1882 some 57,000 tons of sugar were produced from an estimated area of 23,000 acres, or approximately 2½ tons per acre; in 1904 from about 92,000 acres of land in sugar cane a yield of 4 tons of sugar per acre was realised; and in 1917 about 645,000 tons of sugar were made from cane grown on some 120,000 acres, or a little less than 5½ tons of sugar per acre, which will clearly show the great and steady progress made in the production of commercial raw sugars in this outpost of civilisation.

The main factors which entered into the development of the chief industry in the Hawaiian Islands may therefore be recognised as two:—

1. The advantages afforded to the Hawaiian sugar planters by the admission of their products by treaty free of duty into the American market, whereby the sugars in question brought enhanced prices by reason of the duty levied on all other sugars entering United States ports from foreign countries.

2. The highly developed system of co-operation amongst the Hawaiian planters themselves, which extended from the supplying of labour to till the lands on the various plantations, to an advisory oversight as to cultural and manufacturing operations, and to the marketing of the finished product.

It must be clear from the foregoing relation that these two principal factors are so interwoven that the absence of either would have rendered of little avail the effect of the other. Suppose, for a moment, that the United States Government, instead of admitting Hawaiian products to its markets duty-free, had declined to enter into reciprocal relations, what encouragement would there have been to continue investment in a struggling industry in a country the native race of which could not furnish labour enough even to keep in cultivation the small area of land then under cane? It is manifest that there would have been none, and there being none, capital would not have been forthcoming for further development.

Without capital, or the returning of the profits into the business, which amounts to the same thing, co-operation amongst the planters would not have availed to produce sugar at such sufficient profit that a portion of such profits could have been set aside for the various purposes described in the Charter of Incorporation of the Planters' Labour and Supply Company, and later in that of its successor the Hawaiian Sugar Planters' Association.

On the other hand, had the Hawaiian planters been satisfied with the era of prosperity which followed the enactment of the Treaty of Reciprocity mentioned in this paper, and had they taken their profits without providing for expansion in the future, and for improvements in many directions, it is easy to realise that the sugar industry in Hawaii would never, by reason of lack of the requisite knowledge, have reached its present position; nor would it have been

(as it has been) the main inspiring cause for the establishment of two great steamship lines for the purpose of carrying products and passengers between the islands and the mainland of the United States, nor would the Territory of Hawaii have become the war-time asset of a mighty nation which now it is.

INDIAN INDUSTRIES.

I.—Sericulture and Silk Manufacture.

A number of articles on Indian industries are included in the appendices to the report of the Industrial Commission presided over by Sir T. H. Holland. One deals with sericulture and the silk industry, and is based on information collected by Professor H. Maxwell Lefroy in the inquiry conducted by him, with the assistance of Mr. E. C. Ansorge, I.C.S.

There are, it is pointed out, three tracts in which sericulture is an industry of some importance: (1) In the south of India, the southern half of the Mysore plateau, with the adjoining taluk of Kollegal in the Madras Presidency; (2) Bengal, chiefly in the districts of Malda, Murshidabad, Rajshahi, and Birbhum; (3) Kashmir and Jammu, with the neighbouring sub-montane districts of the Punjab. There is also a considerable industry in Chota Nagpur, Orissa, and part of the Central Provinces, dependent on the *tasar* silkworm, and in Assam, on the *muga* and *eri* silkworms. The *tasar* is stated by Mr. Lefroy to be a wild silkworm, never successfully domesticated, which lives in forest areas chiefly, and which feeds on a variety of trees. The *muga* is a semi-domesticated worm reared entirely in the open on trees, chiefly *soom* (Machilus bombycina) and *hualu* (Litsaea polyantha). The *eri* is a domesticated worm yielding a silk which cannot be reeled but has to be spun, its principal food being the castor plant.

From the early days of the East India Company in Bengal silk was an important article of trade. From 1776 to 1785 the export of Bengal silk to England averaged 560,285 lb., and it is probable that this figure only covers reeled silk. Whether the industry made any great progress in the nineteenth century or not depends upon this point, as the total figures usually quoted from the sea-borne trade returns for the exports of Indian raw silk include not only reeled silk, but chassam, or silk waste, and silk cocoons. The exports reached their highest level in the years 1866 to 1874, when the average annual exports were 2,203,000 lb., of which not more than 600,000 lb. were reeled silk. The development of exports during that period is due to the work of Mr. Lister, afterwards Lord Masham, who introduced methods and machinery for spinning silk waste and created a demand for this material.*

On the assumption that the Indian production of silk is at least equal to twice the export of chassam, the sea-borne trade statistics yield no evidence of any serious decline, the falling-off in the production of Bengal being fully compensated for by the expansion in Kashmir and the south of India. Taking the export figures for chassam as a guide, the Indian production of silk during the last thirty years has ranged between two million and two and a half million lb. The exports of raw silk reached their maximum in the years 1906-07, when they averaged over 750,000 lb., and they have fallen since to 82,700 lb. in 1914-15, recovering in 1916-17 to 218,000 lb. In the same year the exports of chassam and cocoons amounted to 1,325,467 lb.

The South Indian silk industry is of comparatively modern origin; it is supposed to have been started by Tippu Sultan with seed received from China, and it is now responsible for two-thirds of the total output of silk in India. Both in Bengal and the south of India silk production is by multi-voltine worms fed on the leaves of the shrub mulberry. In Kashmir, where the industry is now a State monopoly, the tree mulberry is the source of leaves, and only univoltine worms are grown. The first attempt by this State to develop the industry commenced in 1869; but, owing to the appearance of pebrine, it collapsed within ten years. In 1895 a second attempt was made which, as soon as the futility of relying upon local seed was realised, yielded successful results. Development has now reached the limit prescribed by the number of trees available for leaves, and the State derives from the monopoly a net revenue of about 11 lakhs of rupees per annum. The output of silk is approximately 100,000 lb. of reeled silk a year, the whole of which is exported. But the conditions under which sericulture has been developed in Kashmir are unique.

The following table, taken from a paper contributed by Professor Lefroy to the Royal Society of Arts and published in March, 1917, furnishes approximate figures regarding the production of mulberry silk in India in the year 1916:—

Mysore	1,152,000 lb.
Bengal	600,000 ,,
Madras	400,000 ,,
Kashmir	96,000 ,,
Burma	15,000 ,,
Assam	12,000 ,,
Punjab	1,800 ,,
Total	2,276,800 lb.

* For this and other services rendered to the textile industries, he was awarded the Society's Albert Medal in 1886.

These figures agree very closely with the estimate of silk production based upon the exports of chassam, and show clearly the very slight effect which the war has had upon the Indian silk industry. The growing prosperity of the country enables it readily to absorb large quantities of silk, and the diminished exports are probably due to the better prices obtained in India.

There is not the least doubt, the Commission say, that the present unsatisfactory condition of sericulture in India is due to remediable causes. In the evidence tendered by Professor Lefroy he has definitely stated that large tracts of India are suitable, and that much of the silk, both raw and manufactured, now imported might be produced in the peninsula. The imports amount to more than $3\frac{1}{2}$ crores of rupees. He proposes the establishment of an Imperial Department of Sericulture. The Commission think that the object in view can be secured by the employment of an imperial expert located at a suitable centre, but the difficult work of investigating local problems and of demonstrating the results can only be successfully achieved by an agency with local interests.

Arrangements for distributing disease-free seed and more hygienic methods in the rearing-houses are placed by the Commission before the utilisation of new areas. "There is, of course, no reason why efforts should not be made to introduce sericulture in other places, where the natural conditions are suitable, but in the beginning at any rate this should only be done where it is probable that the industry will be welcomed and will expand freely as soon as it has been demonstrated as a certain addition to the resources of the people." One thing to be avoided is offending the prejudices of the people.

While Professor Lefroy draws no distinction between sericulture and the silk industry so far as the organisation he proposes is concerned, the Commission are of opinion that a clear line of demarcation should be drawn. "The duties of the silk rearer should end with the production of cocoons. Sericulture is, and should remain, a cottage industry; but the subsequent preparation of the silk for the market is best undertaken on a large scale and with modern machinery. The success of the Kashmir filatures is evidence in favour of this view. There is no difficulty about the marketing of silk properly reeled. Different markets require different qualities of silk, and all that is necessary is that attention should be paid to these points."

Inquiries seem to indicate that in Southern India, at all events, elimination of the disease that is now greatly restricting profits would more than double the output of silk; but in tracts where the industry is dependent upon mulberry trees private initiative cannot be relied upon to bring about any extended development. The only remedy is for the Government to foster the planting of trees. But the development of sericulture in India, the Commission submit, "will have little effect one way or the other upon the future of the manufacture of silk in India." The Indian silk weaver is already largely dependent upon China for raw materials. Owing to the increased demand for his goods he has attempted to improve his methods of production, and if given special technical instruction "there is hardly any doubt that he could successfully compete with the manufactured goods which are now so largely imported." The weakest spots, apart from sericulture, are declared to be the primitive and inefficient processes used in preparing the silk yarn. "It is desirable that attention should be drawn to the necessity for improving these, and the establishment of model silk filatures, twisting mills, and dye-houses seems clearly indicated. To such factories, for the preparation of silk yarn, silk-weaving establishments may well be attached, as it is not unlikely that the same advantages may accrue therefrom as have resulted from the addition of weaving-sheds to cotton-mills."

TRADE IN THE FIJI ISLANDS.

His Majesty's Trade Commissioner in New Zealand reports that a very important factor in the trade of Fiji is the Chinese and other native participation in the distributing trade of the island. The Chinese element in particular is very strong. Some of the large Chinese traders in Suva are very strongly backed financially by large Chinese traders in Sydney and in China, and it is reported that one Chinese firm is the wealthiest individual firm in Fiji. In addition to these Chinese traders there is a disposition on the part of Japanese firms to open up in Fiji. One or two of these firms have been in existence in Suva for some time, and during recent years they have occasionally brought down schooners themselves with cargo for their own stores and for wholesale trade. Another Japanese firm which has opened in Suva since the war has worked up a large business on an indent basis, not only amongst the small native firms but also amongst some of the largest European firms. In addition to these firms, which may be regarded

more or less as wholesale firms, there is a large number of Chinese traders right throughout the group, and it is common knowledge that these small traders never deal with a European house if they can get what they want from a Chinese house. There is thus a strong foreign and particularly Eastern element throughout the trading interest of the group. British trade in the future has more to fear from competition from the East than from any other quarter, and the existence of this Eastern element in Fiji trade will accentuate the possibilities of this competition as its knowledge of trading methods expands. The Commissioner thinks that British firms after the war cannot afford to maintain the detached attitude towards Fijian trade which they have taken up in the past. The trade in the most important lines is for the most part British, with one or two outstanding exceptions, but Japan in particular is in a very favourable position to secure trade in the islands, and there is no doubt that firms in that country will make every endeavour to increase their share of the business. If the problems which face Fiji are settled satisfactorily, a big development is sure to take place in the next few years, a large population will spring up, and the inward trade will become relatively important. At present it is not very large, but in some important lines it is large enough even now to make it worth while for firms at home to protect their interests by constant attention.

One of the chief steps which should be taken to place British firms on a basis corresponding to that on which foreign firms stand, would be the establishment of direct shipping facilities between Fiji and the United Kingdom, in order to ensure our recovery of the copra trade, which is in danger of being lost, and also to facilitate the importation of British goods at prices low enough to give them a reasonable chance of holding their own against foreign competitors in trades which have always been essentially British, and of endeavouring to compete with foreign firms in trades which are primarily foreign.

DRAUGHT CAMELS.

Writing in the *Journal d'Agriculture pratique*, Mr. F. Couston, Agricultural Engineer of the South Algerian Territories, gives some interesting particulars of the use of the camel in the Algerian Sahara as a draught animal. It is little used as such, he says, but this is a mistake, as it is fairly intelligent and can be well broken in. Were it used for draught purposes many agricultural works could be carried out that would greatly increase soil productivity in many regions of South Algeria where horses and mules are few and costly, or even absent. If the camel were harnessed to the plough vast regions still uncultivated could be made productive, and thousands of acres could be sown down to wheat.

Camels are little used for ploughing in Algeria, while the practice is quite common in Tunis. Thus the Sfaxiens plough their immense olive groves with camels, turning round and round the trees, which shows the animal can be well broken in. In Tunis camels are harnessed to a small cart with two high wheels called "araba," and used for most of the carting. Mowers, reapers, binders, cultivators, can be drawn by camels, either singly or in pairs. This has been shown at the Agricultural Experiment Institute at Tripoli, where barley was harvested with a harvester drawn by two camels harnessed abreast.

The camel can be also harnessed to machines for raising water, as is done in Mzab. Breaking in the draught camel is, according to Lieutenant Bel, "not difficult, as the camel is rather timid than obstinate; brutal treatment must be avoided if quick results are wanted; the voice, a movement made with a stick or whip, mostly suffice to urge them on. As with the horse, the camel must be accustomed to walking with complete harness before it is put to draw, care being taken that the men pull gradually on the swingle-trees, while as many camels as possible should be placed abreast."

The author records a very successful ploughing match with camels at Biskra, in February, 1918, when seventy competitors took part. It would be interesting, at the annual competitions for distributing prizes to camel breeders, to include a class for draught camels, together with suitable tests.

CANE-SUGAR INDUSTRY IN WESTERN VENEZUELA.

The cane-sugar industry in a certain form has existed for a long time around Lake Maracaibo. There were established a large number of small mills making a brown sugar called papelon, or panela, put up in blocks like maple sugar, and polarising from 70° to 75°. This sugar was made only for the local market and Curaçao, practically none being exported to other countries until 1916, when, owing to the high price and scarcity of sugar, about £3,100 worth of papelon was shipped to England and £140 worth to the United States. The total amount of papelon exported from Maracaibo in 1916 was 3,325,783 lb., valued at £14,300, against 2,912,780 lb., valued at £10,000, in 1915.

Accoring to a report by the United States Consul at Maracaibo, the manufacture of sugar for export to the United States had its inception in the lowering of the American duties under the Tariff Act of 1913, but factories were not completed for operation until the autumn of 1915, when the grinding season began. During the last months of 1915, £11,600 worth of sugar was invoiced for export to the United States. Four factories, making centrifugal sugar, were erected on the south and east sides of Lake Maracaibo, at Bobures, and La Ceiba, as follows:—

Venezuela Sugar Company, at Bobures; general

office, Maracaibo. Name of factory, "Central Venezuela." Acreage of cane, 4,000.

Central Azucarero de la Ceiba; general office, La Ceiba. Name of factory, "Central La Ceiba." Not operating. Acreage, 1,400.

Central Azucarero del Zulia, at Bobures; office, Bobures. Name of factories, "Central Sucre," a new and large factory, and "Central Banco," both at Bobures. "El Banco" is operating. Acreage, 2,000.

The sugar from these factories exported to the United States generally polarises around 97°, and is intended for the refineries. In 1915, 1,955,784 lb. of sugar were shipped to the United States; in 1916, 14,997,501 lb.; and in 1917, 24,811,567 lb.

It is reported that a much larger quantity of cane per acre is produced in Venezuela than in Cuba or other cane-sugar countries, but that the sugar content of the cane is much less, the extraction being only 6 to 7 per cent. of the weight of the cane in Venezuela against 10 to 14 per cent. in Cuba, Hawaii, and elsewhere. Another drawback to the industry at Lake Maracaibo is the climate, which, it is said, tends to discourage even native labour.

There are some twenty-five papelon mills in the vicinity of Bobures and Encontrados del Zulia, each with its cane plantation. One of these mills makes white sugar, but only for the local market.

GENERAL NOTES.

Lead-poisoning and Women.—Bulletin 253 of the United States Department of Labour Statistics discusses the susceptibility of women to certain forms of lead-poisoning. Before the war few women in America were employed in lead industries, while in England they are barred from lead works. Some German statistics tended to show that women were not really more susceptible than men, but that the sufferers were generally a weakly, badly-nourished type of women, not fit for hard work, who drifted into lead works, and this seems to be confirmed to a certain extent in America. In the pottery industry more women suffer from lead-poisoning than men; but the men belong to a flourishing trade union and draw good pay, whilst the women have no organisation and are underpaid. In the tile works of the Zanesville district, where men and women are of the same economic class, and badly paid, women show a slightly greater susceptibility. All statistics seem to agree as to the fact that lead-poisoning takes peculiar forms in women, and renders them unfit to be mothers, and that they should not be allowed to have anything to do with lead and lead compounds.

Railway Material Exports.—The Board of Trade returns show the value of the railway material exported during the first five months of the present year to be as follows (the corresponding figures for 1918 are added in brackets): Locomotives, £365,496 (£691,813); rails, £601,876 (£263,719); carriages, £129,806 (£382,180); wagons, £389,271 (£128,545); wheels and axles, £162,162 (£173,518); tires and axles, £372,249 (£247,272); chairs and metal sleepers, £87,033 (£26,604); miscellaneous permanent way, £318,046 (£269,389); total permanent way, £1,026,142 (£565,727). The weight of rails exported was 36,884 tons (13,875 tons), and of the chairs and metal sleepers, 5,254 tons (1,832 tons). Of the rails India had in May to the value of £158,583, the Straits Settlements £22,155, and New Zealand £51,951.

Diamond-cutting Industry.—Referring to the scheme for the transfer of the diamond-cutting industry to South Africa, the *Horological Journal* says: "Certain London capitalists, whose names have not hitherto been disclosed, have assured the [Union] Government of their willingness to spend £2,000,000 on the construction of factories, etc., provided suitable encouragement is afforded. The Government has not yet reached an understanding, but in the meanwhile are promoting the Diamond-cutting Bill, enabling agreements to be entered into for the establishment of cutting factories, subject to Parliamentary ratification. It is expressly stipulated that there shall be no monopoly. The chief value of the Bill consists in the fact that it ensures the diamond-cutters a regular supply of diamonds at market price, thus preventing a possible boycott. It appears that De Beers are hostile to the scheme, the Kimberley Board maintaining that is unsafe to allow diamond-cutting in South Africa except as a Government monopoly, owing to the risks of illicit dealings. Sir David Graaf, who carried on informal negotiations in London on behalf of the Government, stated in the House that diamond-cutting is easily practicable in South Africa. The trade can be quickly learnt, and would provide employment for ex-soldiers."

New Zealand Shells.—Attention is called, in the *Board of Trade Journal*, to the possibility of utilising New Zealand shells in the manufacture of buttons. Samples of these shells may be seen at the Department of Overseas Trade. Two varieties of shells are found in New Zealand waters, namely, the paua (*Haliotis iris*) and the toitoi (*Astræa sulcata*). They both occur in great numbers on the rocky coasts near the low-tide mark, the paua being far the commoner. Since these shells have never been sought for commercial purposes, there is no way of ascertaining their cost, but it is understood that they are very easily gathered as the tide ebbs and flows on the sandy beaches about the islands. The paua shell was much used in the past by the Maoris to ornament their woodwork carvings, and of late years it has been made up into brooches, tiepins, etc., and inserted into the handles of pocket knives with good effect.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—July 25, 1919.

No. 3480. AUGUST 1, 1919. Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,480. VOL. LXVII.

FRIDAY, AUGUST 1, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

GENERAL MEETING.

The Council hereby convene a General Meeting of the Fellows, to be held at the Society's House, John Street, Adelphi, on Monday, August 11th, 1919, at 4 p.m., for the purpose of electing His Royal Highness the Prince of Wales, K.G., a Fellow of the Society.

(By order of the Council),

GEORGE KENNETH MENZIES,
Secretary.

July 29th, 1919.

SOME ECONOMIC ASPECTS OF COTTON AND ITS SECONDARY PRODUCTS.*

By ED. C. DE SEGUNDO, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.

Two hundred years or so ago cotton spinning was unknown in Great Britain, and the first attempts to introduce this industry met with the most stubborn and uncompromising opposition at the hands of those interested in the manufacture of woollen and linen goods. Indeed, it is stated that early in the eighteenth century a statute was passed by the Legislature prohibiting the manufacture of cotton goods, and ladies who wore cotton dresses made from the beautifully designed fabrics imported from the East were mulcted in a substantial fine. Nevertheless, in spite of difficulty and disappointment, persecution and even banishment, the pioneers of cotton spinning persevered in their efforts, and towards the close of the eighteenth century the manufacture of cotton goods in this country gave employment to about 100,000 men and to about 190,000 women and children, and has since become one of the largest staple industries of this country. The average annual consumption of raw cotton in the United Kingdom is about 900,000 tons (about 4,000,000 bales). The average annual value of cotton goods *exported* from this country during the five years preceding the war was about £114,000,000, or roughly one-quarter of the total value of this country's export trade.

The population of the world is approximately 1,500,000,000, of which some 250,000,000 are entirely unclothed, about 750,000,000 are partially clothed, and about 500,000,000 fully clothed. It is no exaggeration to say that cotton constitutes one of the prime necessities of our civilised life, for it is computed that nine-tenths of the clothing of the inhabitants of the world are made of cotton. Indeed, it may be said that the clothing of some 700,000,000 in China and India consists entirely of cotton. When cotton is *dear*, these people can only afford to buy one cotton garment per year, whereas, when cotton is *cheap*, they may buy two or three, or more. You will easily realise that the demand for that class of cotton goods is very materially influenced by the purchasing power of these 700,000,000 natives. Cheap cotton means a bumper trade for Lancashire; dear cotton spells unemployment. Unfortunately, the rank and file in the working classes in England cannot be got to see that the principle of restricting production in order to force up prices and wages is ultimately fatal to trade and industry.

Apart from clothing, cotton enters largely into the manufacture of explosives, paper, celluloid, vulcanised fibre, cellulose acetate (or "dope," as it has come to be more familiarly called), and a host of other commodities.

HOW COTTON IS OBTAINED.

It has been said that anything in the world can be bought in London except a bale of cotton. Whatever may be thought about the

* This lecture was delivered at the British Scientific Products Exhibition on July 23rd, 1919.

truth of the major premiss, the minor is certainly true, and thus it is that most of us in London have but the haziest idea of what cotton is, or where it comes from, so that perhaps a word or two upon its origin may not be out of place in addressing a London audience.

Scientifically speaking, cotton is the *fruit* of a plant which flourishes in sub-tropical climates and is therefore uncultivable in the United Kingdom. It is an annual, and the seed germinates in three or four days after planting. In about two months, when the plant is from 12 to 18 inches high, it flowers, the petals dropping off three days later, when the pod, or "boll" as it is called, begins to form. About one month after, the boll reaches maturity, the plant being then about 4 feet high. The ripening process takes from one to two months more, the boll turning from a bright green to a dull brown. It then cracks open, separating into four or more segments. These segments (technically termed "locks") are seen to contain a white fleecy mass, exactly similar in appearance to "cotton wool," but containing a number of seeds, in the shell of which the cotton fibres are rooted. The contents of the locks are called "seed-cotton," as distinguished from "lint cotton," which is the product *after* the seeds have been taken out, and which is the commodity known in commerce as "cotton."

There are usually from 10,000 to 12,000 plants per acre, and as the area under cotton cultivation throughout the world is probably over 70,000,000 acres, the number of plants must be not far short of 1,000,000,000,000, a number of which the human mind can form no accurate conceptual appreciation, and which I only mention in order that you may have some idea of what is involved in picking the world's annual cotton crop, which is everywhere picked by hand. A certain amount of skill and experience is required for picking, because only the really ripe bolls should be garnered, otherwise the quality of the cotton may be seriously impaired. It is chiefly on account of the necessity of discriminating between the bolls that are ready to be picked and those which are not, that no mechanical cotton picker as yet devised has been found satisfactory in practice. An average of 100 lbs. of seed-cotton may be taken as a fair day's result per picker over, say, three "pickings-over" per season throughout the world, so that a vast army of pickers is required to gather in the world's crop of some 17,000,000 tons of seed-cotton, and the cost cannot be less than £75,000,000 sterling per annum for wages alone.

The Value of the Seeds in the Seed-Cotton.

The "lint cotton," *i.e.*, the product we familiarly term "cotton," is separated from the seeds on which it grows by a machine called a "gin." What remains after ginning is termed "cotton-seed," and up to about the year 1860 the cotton-seed not used for replanting was practically entirely wasted.

Between 1860 and 1870 enormous heaps of cotton-seed, lying about in the neighbourhood of the ginneries, were familiar sights throughout the cotton growing districts in the United States, and it became necessary to introduce legislation, on sanitary grounds, to compel the planters to burn or otherwise destroy the accumulation of cotton-seed. The event has since proved that incalculable quantities of valuable foodstuffs, both for man and beast, were thus literally thrown away.

Although the employment of cotton in the East for textile purposes dates from the remotest days, there does not appear to be any record of oil having been extracted from the cotton-seed until comparatively recently, historically speaking. The Chinese and other cotton growers in Asia are known to have ground the whole seed in rudely constructed mills for a very long time. The oil thus obtained was used for illuminating purposes, and the residue of the seed given to cattle. The first mention of cotton-seed oil among western nations is probably that relating to a demonstration of the crushing of cotton-seed and the extraction of oil in the presence of the secretary of the Society of Arts in London in or about the year 1783. As a consequence of this experiment, the Society, in that year, offered its gold medal to any one who should express one ton of oil from cotton-seed and make a feeding-cake suitable for cattle from the residue of the seed. The Society's offer was renewed for six consecutive years, but no one qualified for the medal. About the year 1832 a small cotton-seed oil mill was set to work in the State of Georgia (U.S.A.). The growth of the industry was, however, very slow. In 1860 there were only seven such oil mills in the United States. In 1870 there were twenty-six. Since then the development has been extraordinarily rapid. In 1900 the number had increased to 357, and to-day there are between 840 and 850 mills crushing cotton-seed in the

United States. The circumstances attending the development of the cotton-seed oil industry during the past fifty years were recently referred to by Mr. J. W. Pearson, Chairman of the British Oil and Cake Mills, Limited, as one of the most wonderful romances of commercial history. The oil extracted by the American method is admittedly unrivalled for the manufacture of the highest grades of margarine, compound lard, and other substitutes eminently fit for human consumption, while the by-products of the refinement of the high-grade oils, and sometimes the whole of the crude oil obtained from inferior cotton-seed, are used for the manufacture of soap.

The world's average annual production of cotton-seed is probably about 11,000,000 tons, of which rather more than half is grown in the United States. This quantity of seed contains, potentially, about 2,000,000 tons of oil and about 8,000,000 tons of feeding-cake for cattle. Of course, the whole of the world's production of cotton-seed cannot be brought to market, but in the United States, where the cotton-seed oil and feeding-cake industry has been developed practically up to the limit of the annual production of cotton-seed, the value of the cotton-seed produced in that country in 1917 was between £60,000,000 and £70,000,000 sterling. On the American system the seed is split open in a decorticating machine and the kernel of the seed extracted, the latter alone being crushed for the manufacture of oil and feeding-cake.

A crop of 6,000,000 tons of cotton-seed in the United States (about 90 per cent. of which finds its way to the crushing mills) would yield about 900,000 tons of crude oil, over 2,500,000 tons of decorticated feeding-cake, and over 2,000,000 tons of seed-remains, or decorticated cotton-seed hulls as they are called. The proportion by weight of residual cotton fibres on American cotton-seed to that of the actual shell of the seed is roughly as 1 is to 3, so that about 600,000 tons, or about 10 per cent. of the original weight of the cotton-seed consists of short residual cotton fibres which until a few years ago were looked upon as practically a waste product.

Cotton-seed Flour as a Diluent for Wheat Flour.

The method of milling cotton-seed adopted in the United States lends itself to the preparation of a highly nutritious flour fit for human consumption from the remains of the kernel after the oil has been extracted. This flour, which is known as "Allison" flour, after its originator, Colonel J. W. Allison, of Ennis, Texas, one of the "doyens" of the cotton-seed oil industry in the United States, contains about 55 per cent. of protein and fat and is practically starch-free, whereas, as is well known, ordinary wheat flour contains a very high percentage of starch and only about 11 per cent. of protein and fat. Thus, cotton-seed flour contains a high proportion of that mysterious substance "protein," without which animal life could not be sustained. Bread made from a mixture of 20 per cent. cotton-seed flour and 80 per cent. wheat would show on analysis about the same proportions of protein and fat as those in first quality lean meat, and cotton-seed flour has, it is stated, been largely used in the United States during the war, and has been officially recommended by the United States Government as a diluent for wheat and as a substitute for meat. I dealt in detail with cotton-seed flour and its bearing upon some economic questions in this country in a paper read before the Society of Chemical Industry in March of last year. The only objection to the employment of cotton-seed flour is its colour, which, as you will see from the sample passed round, is a bright yellow, and necessarily imparts some of the colour to the bread, even when the quantity used in admixture with the wheat is as low as 5 per cent. The little rolls on the lecture table are made from a mixture of about 5 per cent. of cotton-seed flour and 95 per cent. of wheat flour. You will see that even this small proportion of cotton-seed flour has given a distinct yellow tinge to the bread, but upon tasting these rolls (which you may do with perfect safety) you will, I think, agree that the flavour is in no way impaired, and, indeed, in the opinion of a large number of people who have eaten cotton-seed bread, the taste is rather improved.

Experiments are now being carried on with the object of discovering some means of bleaching this flour, and in the event of a successful method being worked out, a very wide and important field of usefulness will be opened for the employment of cotton-seed flour in this country, which would not be without some effect upon the cotton-seed oil industry in the United Kingdom, and would also touch the very important question of our wheat imports. It is not generally known that for many years before the war 80 per cent. of our annual consumption of about 6,500,000 tons of wheat, or roughly 5,000,000 tons, had to be imported.

Yet such is the fact, and it is to be hoped that the object lesson this nation has received during the war as regards the dire results of any serious interference with our overseas traffic will not be lost upon those whose business it is to guide the destinies of the nation and of the Empire.

Value of the Secondary Products of the Cotton-seed.

We have now seen that the cotton plant provides us with a fibre of spinnable length which forms one of the chief constituents of our clothing and of other commodities in daily use; with valuable foodstuffs for our cattle; with oil which, when refined, is indistinguishable from olive oil except by an expert (and is also made into an excellent butter substitute); and with by-products from the refining of the oil which are used in soap-making. This does not by any means exhaust the list of useful things derivable from the cotton plant. The number of these derivatives, as will be seen from the chart hung upon the wall, is very large, and is constantly being added to.

Time only permits of my dealing to-day with one of these secondary products, which, however, may be said to be one of the most important, inasmuch as it is related to a question which, it is no exaggeration to say, is of supreme, indeed vital, importance to the future of our economic position in the world, namely, the question how the problem of an adequate supply of cotton for the world's present and future requirements is to be solved.

The Removal of Residual Fibres a Difficult Problem.

After the fibres of spinnable length have been removed from the seed-cotton by the action of the gin, and a further quantity recovered by saw-linting devices, it is found that upon about 95 per cent. of the cotton-seed produced, an appreciable quantity of cotton fibre still remains adherent to the seed. These short fibres have long been known to be suitable for many industrial purposes if only they could be recovered in a sufficiently clean condition at a sufficiently low cost. The difficulties in the way of accomplishing this mechanically on a commercial scale appeared to be insuperable for a number of years, and it is stated that hundreds of thousands of pounds were spent in fruitless attempts on both sides of the Atlantic. Such fibres were looked upon as a waste product until about seven years ago, when I was fortunate enough to work out a machine which successfully separated them out from the decorticated hulls of the cotton-seed produced under the American system of manufacturing cotton-seed oil. These machines have been at work in the United States commercially since the autumn of 1913, and a good many thousand tons of such fibre in the form of explosives were used by the Allies during the war. About five years ago I was led to attempt the solution of a somewhat similar problem involved in removing these residual fibres direct from the cotton-seed, and the machine which I shall have the pleasure of showing you in action at the conclusion of this lecture is the result of these efforts. This machine removes from the woolly varieties of cotton-seed such of the residual fibres as are not recoverable efficiently or economically by saw-linting or other existing devices, and delivers them in a form so free from the dirt and débris always present in the cotton-seed of commerce, that the highest grades of paper, artificial silk, vulcanized fibre and other commodities can be manufactured from the product of this machine, which is termed "seed-lint" to distinguish it from the "hull-fibre" recovered by the other machine to which I referred above. Upwards of 10,000 tons of the residual fibres obtained by my machines in the United States from the hulls of cotton-seed have now been used in Great Britain, in France, and in the United States, for the manufacture of high-grade papers, of explosives, and of vulcanized fibre. "Seed-lint" is, of course, identical in its characteristics with "hull-fibre," but is superior in quality, being exactly the same material, but removed from the seed *before* decortication. "Seed-lint" has been exhaustively investigated by the well-known firm of Cross & Bevan, Analytical Chemists, of London, who pronounce it to be "a new and superior product which, as regards chemical composition, approximates to that of raw long cotton." Messrs. Cross & Bevan also draw attention to the fact that "seed-lint" fulfils the most exacting requirements for the production of cellulose acetate. Courtaulds, Limited, the well-known makers of artificial silk, have tested seed-lint for their special purposes, and have found it entirely suitable. Last year the Ministry of Munitions of War investigated the properties of seed-lint, and reported that they found it suitable for the manufacture of nitro-cellulose powders.

THE REMOVAL OF THE RESIDUAL FIBRES INCREASES THE VALUE OF THE COTTON-SEED.

Apart from the industrial value of these residual cotton fibres, the removal thereof from the seed concomitantly results in a considerable improvement in the seed for the purposes of the production of oil and feeding-cake and in a corresponding increase in the market value of the seed, a fact that has recently been confirmed by the investigations of the engineer and manager of an important seed-crushing mill in England. His figures show that, *on the basis of pre-war trading conditions*, the seed-crusher should realise an added advantage of as much as £2 10*s*. per ton by treating certain varieties of cotton-seed in this machine prior to crushing, as compared with the results obtained in his ordinary practice. Upon the basis of prices ruling to-day, the advantage would be much greater. This gentleman further points out *that even if the value of the residual fibres obtained be entirely neglected*, there still remains a substantial additional profit to the seed crusher. To go into technical details concerning this machine would take us too far afield, and I must confine myself to such aspects of the subject as are likely to interest you from a general point of view.

THE POSITION OF THE BRITISH SPINNING INDUSTRY IN RELATION TO THE SUPPLY OF COTTON.

I said a little while ago that the results achieved by this machine bore upon a question of vital importance to the Empire, namely, upon the question of an adequate supply of the raw material for our great cotton spinning industry. At the commencement of my lecture I gave figures showing that the manufacture of cotton goods constituted one of our largest staple industries, and that no cotton was grown in the United Kingdom. It follows that we are entirely dependent upon overseas for the whole of the raw material used in this gigantic industry. Now, it is not generally known—except by those whose business it is to know such things—that Lancashire is, and has been for years past, dependent upon the United States cotton crop for about 75 per cent. of the raw cotton needed by our spinning mills. Lancashire draws annually about three and a quarter million bales of cotton (about 800,000 tons) from the United States. From Egypt she obtains about 15 per cent. of her annual requirements, or about 150,000 tons; from India about 6 per cent., or about 70,000 tons; and the remainder from other parts of the world. This dependence for so large a proportion of raw material upon one source of supply (the United States) is clearly an unsound policy. We all agree as to the inexpediency of "putting too many eggs into one basket." When, moreover, we consider that the cotton crop in the United States is at the mercy of a climate, the vagaries of which are similar to those in the British Isles (only more intensified in their variations), and that, consequently, the fluctuations in the available supplies of cotton from the United States from year to year are often very considerable, the wonder grows that the Lancashire spinner has delayed so long in taking steps to remedy what he must long have realised to be, to say the least, an unsatisfactory condition of things. There have been, of course, far-seeing men who have ceaselessly urged upon us the necessity of taking steps suitably to increase the cultivation of cotton within the British Empire, but these warnings have been neglected, even as were the timely warnings of Lord Roberts, simply because we are prone to cling tenaciously to the doctrine that "what was good enough for our forefathers should be good enough for us," and to wrap ourselves up in the cloak of insular prejudice and refuse to open our eyes to what is going on outside the confines of this little Island, particularly if it hurts our *amour propre* or is in any way distasteful to us. It has required nothing less than the terribly bitter experiences brought about by the cosmic upheaval through which we have passed during the last five years to tear the scales from our eyes and awaken us to a sense of our lamentably real insecurity, both industrial and commercial.

In the year 1907 a cotton conference was held at Atlanta (Georgia, U.S.A.), at which American and European cotton manufacturers were assured by American cotton growers that they could rely with confidence upon the American cotton belt furnishing all the cotton required by the world's ever-increasing demands, and that, therefore, the opening up of other cotton fields was wholly unnecessary. At the same time it was made clear that the United States intended to develop the cotton spinning industry within their own borders, because the Director of the United States Bureau of Agriculture told the delegates at the same conference that he looked forward to the time when the United States would work up the greater part of their cotton crop instead of exporting it, and thus retain the enormous profits arising out of

the further manipulation of this valuable commodity. Let us see what has happened to the cotton crop in the United States since 1907. I have hung up on the wall a diagram showing the percentage of the United States cotton crop taken by American spinning mills from the year 1865 to 1918. It will be seen that whereas up to 1890, about 30 per cent., on the average, of the United States cotton crop was absorbed by the textile industries in that country, a gradual increase took place between 1890 and 1910, and that from 1910 to 1918 the increase has been very rapid, the proportion of the crop now spun in American mills having reached nearly 60 per cent.

The prognostications of the Director of the Bureau of Agriculture have been realised, so far as spinning the greater part of the United States crop in American mills is concerned, but where is the promised increase in the American production which was to have provided for the world's needs? The size of the crop referred to at this conference at Atlanta in 1907 was 13,500,000 bales. In 1909 the crop was about the same; in 1912 there was a bumper crop of 16,000,000 bales; in 1913, 1914 and 1915 the crops were 14,000,000, 14,500,000 and 15,000,000 bales respectively. In the years not mentioned, the crop was smaller than that of 1907. In 1916 the crop fell to 12,800,000 bales; in 1917 to 12,700,000 bales; and in 1918 to 11,800,000 bales. According to the *Times Trade Supplement* of Saturday, July 5th, 1919, the world's total production of cotton has fallen continuously, from nearly 30,000,000 bales in 1913–14 to 23,000,000 in 1917–18. Now, in a recent review of the world's requirements of cotton and the available sources of supply, Professor John A. Todd, a leading authority upon cotton economics, pointed out that the world-demand for cotton calls for an annual *increase* in the production of about 1,000,000 bales annually, and that this increase must be cumulative, that is to say, if the world's production is the same for two consecutive years, the production in the third must be *two* million bales more. Instead of any *increase*, there has been a continuous *decrease* in production for the last four years, and while, of course, the dislocation in labour conditions caused by the necessity of sending so large a number of agricultural labourers to the Front, has no doubt affected production of all commodities, it is not very easy to see how this condition of things is to be speedily remedied, so far as the cotton cultivation in the United States is concerned, because the picking of cotton is essentially a "black man's job," and the negro in the United States is now able to command from three to four times as much for his labour as he did in pre-war days. Not many weeks ago, a prominent American authority on the subject, in commenting upon a lecture I gave at the Textile Institute at Manchester, in which I strongly urged the necessity of "Empire grown cotton," said to me that Lancashire need never fear a shortage of cotton, because there was sufficient cultivable land in the cotton belt to produce 200,000,000 bales of cotton per annum. My reply to him was, that I had no doubt that that quantity of cotton could be *grown*, but whence did he propose to obtain the labour to *pick* it? My friend had no answer to make to this. There is not much difficulty about growing cotton, the difficulty is to secure suitable labour at a suitable price for picking it.

The British Cotton Growing Association, whose labours in the interests of "Empire cotton" are too well known to need any encomium from me, have already proved the existence of enormous areas in our possessions and protectorates in Africa, where climatic and other conditions are favourable to the cultivation of the American variety of cotton, but the labour question and the question of transport stand in the way of any rapid materialization of what otherwise would be most eminently desirable projects. Uganda appears to be the district, in Africa, whence we are most likely to make rapid progress in cotton cultivation. In 1904 only a few bales were grown. In 1908 the shipment of cotton was 4,000 bales, and in 1911 the shipments had increased to 20,000 bales. Had the war not broken out it is estimated that Uganda would have sent us about 40,000 bales in 1914. Similarly, rapid progress is reported in South Africa. While these figures are encouraging, this quantity is but a drop in the ocean compared with the world's needs, and there seems little doubt that we must look to India as the source whence we may most readily and speedily obtain the supplies of cotton for the maintenance of our spinning industry, and bring about the much needed stabilization of prices.

Enough has been said to enable you to realize that we are faced to-day with a very grave and difficult problem in regard to adequate supplies of the raw material. The rapid increase in the proportion of the American crop taken by American mills is alone a serious

menace to the prosperity of our spinning industry; the fact that not only the American crop, but the world's production, has fallen continuously for the last four years means that the very life of Lancashire's chief industry is now most gravely threatened. One remedy is to extend the cultivation of cotton throughout the Empire in the most rapid manner and in the greatest measure possible.

The Industrial Utilization of Residual Cotton-seed Fibres is a Factor in Cotton Economics.

It must not be supposed that the urgent needs of our spinning industry have been neglected by the Government. In 1916 a strong Commission with wide powers was appointed to investigate the undeveloped resources of India, and a voluminous Report was presented in the spring of this year, of which an able summary was submitted by Mr. D. T. Chadwick, I.C.S., Indian Trade Commissioner, in a paper read before the Royal Society of Arts on March 13th, 1919. Attention is drawn on more occasions than one in this Report to the very large potential revenue to be derived from the establishment in India of a scientific cotton-seed oil milling industry to turn to more useful account the two million tons or so of cotton-seed annually produced in that country.

In October, 1917, the "Indian Cotton Committee" was appointed, more particularly for the purposes of enquiring into the practicability of rapidly extending in India the cultivation of that variety of cotton which Lancashire has hitherto drawn exclusively from the United States. This Committee completed its labours towards the close of last year. Its Report is an exceedingly able one, and the recommendations are of a very practical and far-reaching character. Briefly, the general conclusions bear out the statement by Professor John A. Todd, referred to in an earlier part of this lecture, and we may therefore hope that steps will be taken before long effectively to carry out the recommendations of the Committee.

The changes brought about by the war have seriously affected cotton growing conditions in the United States. At the present moment, for good and sufficient reasons into which I cannot enter here, there seems little doubt but that the production of cotton in the United States will continue to decline unless the present situation is grappled with, and the prevailing conditions altered in such wise as to make cotton a paying crop in competition with other crops under a considerable reduction in the present price of cotton. The situation that has now arisen in the United States was seen to be inevitable shortly after the war broke out, and during the month of May last an influential and representative Commission (consisting of prominent American planters, spinners, bankers, and others) arrived in Liverpool charged with the mission of organising a World Cotton Conference in New Orleans in October of this year. The members of the Commission have visited the leading centres of the cotton industry in England, have spent some time in London, and are at present visiting the more important centres of industry on the Continent of Europe.

Mr. Frank Nasmith, editor of the "Textile Recorder," Manchester, who has been appointed European representative of this Commission, tells me that official recognition has been extended to this American Commission by the Board of Trade and the more important institutions in the country connected with the cotton industry. He states that France, Switzerland, Belgium, Czecho-Slovakia, and Poland have also officially recognised the Commission, and are also sending delegations to the World Cotton Conference which is to be held in October of this year.

We have seen that, with the best will in the world, our American friends have not been able to make their production keep pace with their own demands and also with ours, as was so confidently expected at the Atlanta Conference in 1907. The aphorism, "charity begins at home," applies to nations as well as to individuals, and we cannot expect the United States to curtail the development of *their* spinning industry in order that we may be able to maintain *ours*. It is clear that the world is very short of cotton. The prices we have to pay to-day for cotton goods is sufficient proof of that. More cotton *must* be grown, and it is a matter of simple common sense that the cotton we need for the maintenance of our own spinning industry should be grown, so far as possible, within the Empire. In the course of the discussion which followed a paper which I read before the Royal Society of Arts in February last, Professor Todd said that "there were many countries in the world in which cotton could be grown, but the question was whether it could be made to pay in competition with other crops. One of the factors in that question was the by-products that could be realised, and he thought the by-products

obtained from the cotton-seed by means of the author's machine might just turn the scale in many cases in favour of cotton. The importance of these by-products could hardly be exaggerated."

We certainly do not wish to see "nationalized cotton," nor do we wish to produce "Empire cotton" at the expense of "Empire cereals," or at the expense—direct or indirect—of the taxpayer. It is therefore of moment that the cultivation of cotton should be "self-supporting," and should pay in competition with other crops. Hence, the additional revenue derivable from turning industrially to account the hitherto neglected residual fibres on ginned cotton-seed is a factor in cotton economics which we cannot afford lightly to neglect.

WIND MOTORS: THEIR POSSIBILITIES AND LIMITATIONS.

By Captain Faville C. Poulton, O.B.E., A.M.I.E.E., etc.

The wind motor, as a branch of engineering, is probably the oldest and also, until very recent times, the most neglected form of generating power. This is possibly due to the natural disdain one has for anything that can be had for almost nothing, and to the unreliability of the wind. Until lately it could only be used at the moment when it was blowing; but with modern and efficient systems it is now possible to conserve or accumulate this power, and so render it available in the form of energy when and where required. It is a very common thing to hear even experienced engineers say "The wind motor is not efficient." I beg to claim a good case for its consideration on "efficient grounds," if on no others.

There are only three power-producers worthy of notice, namely, coal, water, and air. If we take in each case a plant of the same horse-power, and generate electricity at the same efficiency for the dynamo, we shall have the following figures: Water-power with a modern plant gives 70 per cent.; air with a modern wind motor properly installed gives 15 per cent.; coal with a modern steam-plant coal at 15,000 B.T.U. per lb., gives 13 per cent. Thus I feel that there is room for the wind motor in these days of super-economy in all appertaining to coal usage.

As this article is dealing only with wind motors I will not say anything further about either of the others, except perhaps a word here and there in comparisons.

Wind Measurements and Methods of Measurement.

The wind, at any point of the earth's surface, is constantly varying in strength and direction throughout the year. The change in direction may be momentary, or a decided change in compass direction. The former changes are due to local conditions and influences, such as surrounding objects which may exert their influences by deflecting the wind. These have to be considered by the wind motor erectors, who must choose a position as free as possible from such disturbances.

Whilst it is true that the earth's contour at any given locality has a great influence upon the prevailing winds at that place, at altitudes above the influence of the surface the prevailing direction of the winds in many places is well defined, and at certain places they have the name of "Trade Winds." In a mountainous country the wind naturally takes the direction of the valley.

A wind is not a steady moving volume of air but a series of small waves of wind of varying velocities within the large volume, just as the resultant voltage of an alternating dynamo is made up of many inter-voltages, many of which are higher than the resultant voltage.

The measurement of wind velocities is one of the important duties of the Meteorological Observatory Stations, and self-recording instruments are installed in most of these. These instruments are usually one of two types: (1) Pressure recorders; (2) the "Robinson" anemometer. The latter is the most used, and consists of four semispherical cups, hollow and fixed at the ends of four arms, made so as to be capable of rotation with a minimum of friction. The wind operates on the concave side of one and the convex side of the one on the opposite arm, causing rotation due to the unbalanced pressure. The speed of rotation is calibrated, and forms a record on a drum through suitable gearing on to paper. The pressure-recording instrument responds to the rapid fluctuations of the inter-wind of a steady wind; thus these records give not a line but a series of maximum and minimum readings, just as does the oscillograph with an alternating current.

An examination of the records of the nearest observatory will tell those who propose to erect a wind motor the prevailing direction of the winds and the extremes in intensity, as well as the average velocities.

As a wind motor is capable of taking advantage of winds from any point, it is not of great moment to know the directions from which they come, except in cases when they come from one direction and are of very excessive violence, when the engineer will have to take extra precautions in designing. What interests the air motor engineer is the average velocity over a definite period, and the variation of wind velocities from day to day.

Before deciding upon the type of wind motor, or even whether it is advisable to erect one at all, the engineer should obtain access to the records of the nearest observatory, when it will be quite possible to predict with very considerable accuracy what may be obtained from a motor should it be erected within a definite district and under certain conditions of locality. Thus, *e.g.* it may be pointed out that for one month, taken at random, the number of possible hours was $31 \times 24 = 744$, and the number of hours during which the wind exceeded 10 miles per hour was 307; from this it is seen that, should the motor have been set to operate full load at 10 miles per hour, there was 41 per cent. of the possible time when it could have been usefully employed for full load. There are, I can say, very few stationary steam plants that would be expected to do this, and a steam plant when not in use for short periods consumes coal or fuel, which can hardly be said of the wind motor; and, further, it would in all probability have generated from one-quarter to full power for a further 25 per cent. of the time. It has therefore been possible to have available 41 per cent. of 744 hours full load and 25 per cent. of 744 hours at, say, half load. Assuming a unit of power to be 1 h.p. at the dynamo terminals, the motor would have stored in an accumulator some $(746 \times 307) + (746 \div 2) \times 188 = 229{,}022 + 70{,}124 = 299{,}146$ watts, or 2,990 Board of Trade units. The efficiency of the accumulator is slightly above 95 per cent.; but, taken at a very conservative basis of 90 per cent., there is actually available for operating, lighting, and motors, some 2,971 Board of Trade units.

With reference to average winds, these are for the United Kingdom a little in excess of 16 miles per hour for almost eight hours per day for over two-thirds days in the year. These averages are seasonal, and made up as follows: January, February, and March, 16·8 miles per hour; April, May, and June, 17·2 miles per hour; July, August, and September, 13·6 miles per hour; October, November, and December, 16·5 miles per hour. Also, it is well to note that all winds from north-west, north, north-east, and east, have an average velocity just in excess of one mile per hour of any other compass direction.

The pressure of the wind is not proportional to the velocity, for if a wind of, say, 25 miles per hour gives a pressure of 1·8 lb. per square foot, a wind of 50 miles per hour at the same point would give a pressure of 7·5 lb. per square foot. I say both tests taken at the "same point" advisedly, for altitude has, as I will attempt to show later, to be considered. Thus it is possible to construct a wind motor with a definite sail area that will give theoretically all the following powers with varying wind velocities at one situation and with the barometer constant:—

Horse-power.	Wind at miles per hour.
2	8
5	10·75
7	14
8	16·25
9	19
10	22

With reference to the altitude at which the wind motor is to be erected having any effect upon its efficiency, I believe I am right in saying that this point has never yet received any consideration from the designers or manufacturers, and to my mind it has a considerable bearing upon the resulting efficiency of the plant. At sea-level we have 29·5 in. of mercury, at 1,000 ft. reading 28·5: this, with (as is usually the case in the United Kingdom with high altitudes) a low atmospheric pressure due to rain, will give a further 1 to 1·5 in., bringing it for 1,000 ft. to 27·5, or 27 in. This points to a rarefied state of the atmosphere (as the aeronauts have proved). This rarefication of the atmosphere produces on the wind motor what is the equivalent to the slip on the aeronaut's propeller. Thus a wind with a velocity of 8 miles per hour at this altitude would not produce 2 h.p. as it would at sea level, but 91 per cent. of 2 h.p. Reverting to the number of B.T.Us of electricity produced we should now have only 2,700 instead of 2,971, or a definite loss due to putting up the wrong size of motor of 270 B.T.Us, which, for one month's working, is a considerable loss, especially when efficiency has to be considered, and the extra first cost would hardly be noticed in increase of capital outlay.

The Modern Wind Motor.

The modern wind motor is absolutely unlike its ancestor, which had, as a rule, arms or sails

with a diameter or sweep of up to 40 ft. The modern one has what may be termed a wheel with a number of slats set at an angle. The largest wheels are 50 ft. in diameter, but the majority are from 10 to 15 ft. in diameter; in fact, there is a tendency for the manufacturers to make 12 ft. a standard. These motors are erected upon steel towers which, according to local conditions, may be anything up to 80 ft. high.

The steel tower must be well braced and a ladder provided to give access to the platform at mill head. Water tanks are sometimes mounted some way up the tower, which renders necessary heavier construction to withstand the extra strains and stresses.

The foundations must be of concrete in which the uprights are properly embedded. No departure from this should ever be permitted without the sanction of a qualified engineer, as an overturning wind motor is a very serious catastrophe.

The steel towers are usually of light angle iron. I have seen three-legged motors, but I would strongly deprecate this practice as a false economy, for it renders overturning and buckling more liable to happen. The wheels are constructed of either galvanised iron or wood, the details of construction of these vary in details and principles :—

1. Those having moving vanes or sails.
2. Those having fixed vanes or sails.

Any tendency of the wheel to collapse is overcome by one of two methods :—

1. Extending the axle and attaching, by means of a star casting, guy rods, which are fastened to the wheel at a radius from the centre.
2. By having the radius of the wheel forward of the axle line.

The essential parts of a wind motor are :—

1. The wheel.
2. Method of keeping it up to the wind at all times.
3. Method of transmitting the generated power to the required point.
4. Safety devices such as self-luffing and governing.
5. Starting and stopping gear.

The Wheel.

This can be from 6 ft. to 50 ft. in diameter—the latter is exceptional. The sails are made of either wood or metal. When the cost of aluminium is reasonable this will be an ideal metal for sail manufacture. Metal is better than wood in so much as it can be shaped to the most advantageous curve. (This is a subject that can hardly be entered upon in this article, but I will give any information, if desired. I will only say here that this curve has a very great effect upon the efficiency of the motor at a given wind velocity at a given density.)

Veering Apparatus.

The majority of wind motors have a tail vane upon an extension, upon which the wind acts until it has brought the wheel fully into the wind. When it is desired to stop the motor it is brought parallel with the wheel, thus causing the wheel to come parallel to the wind. This is operated from the ground by a chain.

Unless the tail is the correct size the head of the mill will either oscillate all the time, and thus cause serious unnecessary strains on the whole structure, or it will prevent the wheel rapidly turning to the wind.

Transmission Apparatus.

This depends upon what kind of machinery the motor is intended to operate, for there are various types of transmission—namely, rotary, reciprocating, electric. The first two are commonly used, and the last I am now having constructed for my own use.

Safety Devices.

These are automatic governors to prevent the motor destroying itself by running away in a storm, and are of the following types :—

Automatic alteration of the angle of the sail to the direction of the wind, according to its velocity.

Automatic change of angle of wheel in relation to the direction of the wind.

Starting and Stopping Gear.

In the case of movable sails these are made to go parallel to the wind; in the other cases the tail is slewed round to become parallel with the wheel.

Power of a Modern Windmill (Wind Motor).

If half a dozen wind motor manufacturers were examined it would be noticed that hardly two would quote the same power for the same size of motor, and if this form of prime mover is to have fair play it must have a form of rating that the ordinary purchaser will recognise. The following is my suggestion for the

way in which a specification should be drawn up:—

1. Horse-power required.
2. Altitude or height above sea-level.
3. Wind at miles per hour at which the mill will give horse-power in No. 1.
4. Diameter of wheel.
5. Speed regulation to within x per cent. with fluctuating wind.
6. Revolutions per minute.
7. Can be set to a maximum horse-power at a wind velocity of x miles per hour.

8 miles per hour	and over for	7,708	hours, or	88	per cent.	of possible hours.
10 ,,	,,	6,854	,,	71	,,	,,
12 ,,	,,	5,256	,,	60	,,	,,
15 ,,	,,	3,941	,,	45	,,	,,
20 ,,	,,	2,452	,,	28	,,	,,
25 ,,	,,	1,576	,,	18	,,	,,
30 ,,	,,	700	,,	8	,,	,,

8. Height of tower.
9. Price.
10. Regulation, type of.
11. Braking, type of gear.
12. Throwing out gear, type of.
13. Type of drive.

With this information given, it would be possible to have a definite power for any altitude and wind velocity. In cases where a specially fine speed regulation is necessary—as, for instance, "weaving"—this can be obtained by one of two methods: (1) Cone pulleys connected by a belt; (2) weighted pulley to allow slipping belt. In the case of electric generation with the modern dynamo it is possible for the dynamo to regulate itself to an extent that renders special regulating gear unnecessary, for the voltage is maintained constant at any load from zero to full load.

With reference to the advisability of installing wind motors of large diameters, I am of opinion that it is far more efficient to have many reasonably sized mills than a few very large, for the following reasons: (*a*) Excessive weight of wheel necessary to withstand the stresses; (*b*) large starting torque; (*c*) large and heavy towers necessary; (*d*) great expense from causes (*a*) and (*c*). In fact, for equal safety factors the weight of the wheels should be proportional to the cubes of their diameters. It would require, however, four mills of 6 ft. diameter to equal the power of one mill of 12 ft. in diameter, but this tower would require to be not less than twice the weight of the four smaller towers combined. To sum up, it would be more economical and efficient to have smaller units coupled together for the reasons: (*a*) lower starting torque; (*b*) being separated they would get more wind; (*c*) higher all-round efficiency and easier regulation; (*d*) risk of a complete breakdown reduced to a negligible minimum. It has frequently been stated that a battery of connected wind motors is not satisfactory; but with modern methods this is not only satisfactory but highly efficient.

Taking the average wind for the United Kingdom for 1918, I find that out of a possible 8,760 hours the wind blows at:—

Now, taking the average working week at forty-eight hours and fifty weeks per year, the most economical wind for this would appear to be twenty miles per hour (subject to locality).

The next consideration is, when is the work required to be done? If it is possible to do the work when the wind blows, as used to be the case in flour-milling, the problem is simple, as no accumulation of power is necessary against the times when the wind is not blowing; but as only very few operations can be carried out under these conditions, it is necessary to have some form of accumulator to store the power so that it can be used at convenient hours. This accumulation can be done by several ways, as, for instance: Electrical accumulators; hydraulic accumulators. Each of the above has advantages over the other for certain duties. Thus for a small engineering works the electrical is advisable if machine drive is required, but when hydraulic machines are required the hydraulic accumulator is more suitable.

As to the question of costs, assuming the wind motor to deliver 2 h.p. at sea-level for a wind velocity of twenty miles per hour, the size of wheel would be 16 ft. in diameter, and the cost: Wind motor, £90; accumulators, £80; dynamo, etc., £20; total, £190—say, £200. Interest at 5 per cent., £10; depreciation at 7 per cent., £14; upkeep, etc., £5—total, £29. Thus there is available 2 h.p. for 2,400 hours for £29, which works out at 0·8*d*. per horse-power hour, and there is no power except water that can be generated for this figure in small units. Should it be desired to have a

large unit, say, a mill or lighting plant, it is not advisable to have excessively large wind motors as has already been pointed out, but to utilise a standard size and have these arranged to work together in an efficient manner on to a common shaft.

Among the practical applications to which wind motors can be put, are :—

1. Corn grinding.
2. Pumping.
3. General farm machinery—
   - (a) Power-driven wood saw.
   - (b) Chaff cutter.
   - (c) Swede cutter.
   - (d) Corn crusher.
   - (e) Hay press.
   - (f) Potato-washing machine.
   - (g) Butter-making machine.
   - (h) Cheese-making machine, etc.
4. Workshops—
   - (a) Engineering: lathes, grinders, millers, etc.
   - (b) Joiners: lathes, saws, etc.
   - (c) Smiths, blowers for forges and power hammers, etc.
   - (d) Boot-makers' and repairers' machines.
   - (e) Woollens (knitting machines).
   - (f) Sewing machines.
   - (g) Small weaving machines and looms.
   - (h) Village lighting.
5. Generation of electricity for light and power.

Each of the above requires individual consideration to obtain the best results. To the writer's knowledge there are many plants operating with every satisfaction on Nos. 2, 3, 4, and 5.

COAL-MINING OUTPUT.

Two articles on this subject have recently appeared in the *Times Engineering Supplement.* The first compared the output of coal per man employed in the United Kingdom and in the United States, showing that the larger output in the latter country is due to several causes, of which lie of the coal-bearing strata, greater thickness of seams and lesser depth, are natural. Other causes, mechanical and economic, were dealt with in the second article. In the United States much larger cars or tubs are commonly used for bringing the coal away from the face. The use of these has led to better permanent way, roller bearings, and electric haulage. These cars are built of steel with an oak bottom, and a capacity of three to five tons (2,000 lb.), is secured by increasing length and width only. The gauge is 56½ in. in some few mines, and 48 in. in many others. As a rule the axle is fixed in the wheel, with roller bearings in axle boxes. The greasing of bearings is effected two or three times per annum by a machine which greases the four wheels in one operation by a pressure hose. Progress in the use of coal-cutting machines is so rapid that it is expected to supersede hand-mining in the bituminous districts in a few years' time. The capacity of these machines is constantly increasing. A "combined cutting and loading machine" is mentioned, which can be used in "room and pillar" mining work. This machine is taken into a working place by its own power, and is not removed until the place is worked out. It has feeding movements, an undercutting and two vertical shearing chains, a conveyor to the cutter head, and another which loads on to the car. A mechanically-operated pick knocks down the coal after it has been undercut and sheared. It has also a slack conveyor. These coal-mining machines cost from £200 for a "short-wall" machine, up to £400 for a "long-wall" machine; while £650 is required for an "Arc-Wall" machine. All are electrically driven. A "pillar-drawing" machine is also coming into use.

Quoting a statement of Mr. J. C. Parfitt, of Pennsylvania, it is said, that but a small proportion of the men are practical miners spending their lives in this work; the bulk are immigrants, with no coherence or mining traditions, having no stability, and offering little opposition to change of methods. The article concludes with a tabulated statement of cost of machine mining in certain States of the Union.

WINDMILLS IN DENMARK.

During the coal famine caused by the war many attempts were made to improve the working of windmills geared to dynamos to generate electricity. About 250 installations on farms and small estates have proved fairly satisfactory, according to *Ingeniören.* Many experiments in this connection were carried out by the late Mr. P. la Cour, and a trial mill designed by him is still being used for observation purposes. The following average results have been obtained :—

Velocity of wind (feet per second).	Power obtained in kilowatts.	Number of hours useful wind.	Total kilowatts per annum.
16·4 feet . . .	3·1	1,796	5,600
19·6 feet . . .	6·0	1,080	6,500
23·0 feet . . .	10·9	900	9,800
26·2 feet and above	13·0	1,945	25,100
	Total .	5,721	47,000

During about one-third of the year there was either complete absence or excess of wind, and the force available was very variable. It was nevertheless found possible to save fuel for steam or gas-driven power producers.

The cost per kilowatt from peat gas-fired plants

is appoximately the same as from a windmill-driven installation.

Attempts were made to design three-phase dynamos capable of maintaining constant voltage independent of the speed of the mill, special attention being also paid to automatic adjustment of the sails in order to reduce the cost of attendance. A mechanical contrivance affects a turning movement of the sails, so that during very high winds these occupy a position parallel to the direction of the wind, thus avoiding damage to the mill.

Attention has also been paid to gearing and bearings to minimise losses in transmission from the sails to the dynamo.

MEXICAN AGAVES.

An article in the *Bulletin* of the Pan-American Union gives some interesting facts relating to the agaves or aloes of Mexico, and the methods in which the sap is converted into pulque, the national Mexican beverage.

The agaves of Mexico are very numerous, and some ten of them are suitable for the manufacture of pulque. The plants have a wide range, but are chiefly grown on the plateau at heights of from 2,200 to 2,700 metres (about 7,200 to 8,850 ft.). Plantations are made by utilising the suckers which spring from the roots of the old plants, these young plants being set at wide distances apart in ploughed but unmanured land. Barley, maize, etc., are sometimes grown between the rows, but otherwise the plants are merely left to mature, a process which may take four to seven years. The embryonic flower spike is then removed, and a hollow scraped out at the top of the stem. Into this hollow the sap exudes, and is collected by suction into a gourd every day, and then emptied into a sheep or goatskin receptacle carried on the collector's back. The daily yield of the sweet fluid is two quarts to one gallon, but the plant rarely lives more than 120 days after the beginning of the process. The juice is run into ox-hide vats, and allowed to ferment, scrapings of the pulp of the plant being added. The liquor produced resembles a sour cider, and has a disagreeable odour; it is not, when fresh, a strong intoxicant, but very rapidly undergoes a further change, when it acquires an unpleasant taste and smell and the percentage of alcohol increases. In addition to pulque, a much stronger spirit, called mescal, and comparable to whisky, is made from agave juice. The fresh juice, in the unfermented condition, is known as aguamiel, and is reputed to have marked medicinal qualities. The fact that it ferments spontaneously with great rapidity, however, makes its use limited to the area of large-scale production around Mexico City.

Enormous quantities of pulque are consumed in Mexico, and the manufacture of the sheepskins in which it is carried is a considerable industry. It is obvious that in addition to the climatic conditions involved, its production on any scale demands a large labouring class of low economic standard to carry out the daily collection of juice from the vast plantations.

NOTES ON BOOKS.

A Glossary of Aeronautical Terms. Prepared by the Technical Terms Committee of the Royal Aeronautical Society. Edited by W. Barnard Faraday, LL.B. London: Royal Aeronautical Society. 2*s*. 6*d*.

Recognising the growing need for precision in the terminology of a new branch of science and engineering, the Royal Aeronautical Society decided rather less than two years ago to make a more serious effort than had been attempted previously to supply this want. The strong and representative committee appointed by the Council of that Society, "to ascertain the best words for general aeronautical use," held thirty-six meetings, and the results of their labours are now circulated in a convenient form, not as a completed work, but, in the words of the Chairman, Lieut.-Colonel Mervyn O'Gorman, to "stimulate suggestions for future editions." This "provisional glossary," it is pointed out, has been framed on the following basis:—The coining of new terms has been avoided; terms which, though used in aeronautics, have the same sense as in their ordinary usage, have been excluded with few exceptions; when current usage has been lax, a term has been restricted to that employment which was either dominant or most logically defensible; terms already in common use have been crystallised by clearly defining their application; cross-references have been given to many colloquialisms which have a reasonably wide use, but have not obtained formal status; an agreed series of symbols has been introduced for those mathematical calculations which relate to aerodynamics; terms of which the meaning in aeronautics has been narrowed down to some specialised significance have usually been included; the names used in aircraft stores of parts and materials have been listed and defined where necessary; meteorology and its terms have been included as a part of the science of aeronautics. The work has been prepared in consultation with the British Advisory Committee on Aeronautics and the British Engineering Standards Association. In their desire for uniformity of aeronautical terminology throughout the English-speaking world the Committee sought and gained useful American co-operation. The classification and arrangement appears to have been carefully thought out, but perhaps it would be better if the list of contents were placed at the commencement and not, as at present, on pp. 13 and 14 after the report and appendices.

GENERAL NOTES.

Essays on Industrial Problems.—In an effort to obtain some light on industrial problems of the day, Sir Robert Hadfield is offering £200 in prizes for an essay competition of which the particulars are published by *Unity*, the organ of the National Alliance of Employers and Employed. Essays may be submitted on one of three subjects: (1) A practical scheme for the joint development of industry by capital and labour; (2) the most effective means for the prevention of unemployment; (3) the most effective means for the prevention of industrial disputes. The prizes offered are of £100, £50, and £10, with eight of £5 each. The judges in the competition are the Right Hon. Frederick Huth Jackson, the Master of Balliol, and the Right Hon. Arthur Henderson. Essays, which must not exceed 3,000 words in length, must reach the editor of *Unity* at 64, Victoria Street, S.W.(1), on or before August 30th.

War Memorials Exhibition, October-November, 1919.—The Royal Academy War Memorials Committee is making arrangements for the second section of the Exhibition of War Memorials, to be held at the Royal Academy in October and November, 1919, and to consist of works or designs for works in any class of art or craft selected by the Committee as suitable examples for the guidance of promoters of war memorials. The Committee desires to make the exhibition as fully representative as possible of the various forms which memorials may take, and trusts that artists and craftsmen, and also owners of suitable exhibits, will do their utmost to support the scheme by sending works. It is not intended to show works with a view to copying or slavish imitation, but to assist the public in the selection of suitable designs and of qualified artists, and to suggest the different forms available for memorials. A Bureau of Reference will be provided for supplying applicants with information regarding memorials, artists, and craftsmen. Works and designs for works suitable for war memorials in sculpture or architecture, crosses, decorative paintings or tablets, brasses, metal-work, screens, stained glass, rolls of honour in vellum, etc., tapestry or embroidery, will be admissible for selection by the Committee. Each work or design must be accompanied by the name of the designer and of the executant artist. Special committees will be appointed by the Royal Academy Committee for selecting the exhibits from the works sent in. Schemes which are wholly or largely utilitarian do not come within the scope of the exhibition. The Committee reserves the right of excluding any work which may be considered unsuitable for exhibition. All communications should be addressed to the Secretary, Royal Academy, Piccadilly, London, W.1, and intending exhibitors will be sent forms and labels on application. It is hoped that the exhibition may be open towards the middle of October. Each application for forms and labels should enclose a stamped and addressed envelope, and should be sent in during August. Applicants should state the number of labels required. Works must be sent in on either Monday, September 22nd, or Tuesday, September 23rd, between 8 a.m. and 8 p.m.

Coal and Nationalisation.—The special feature of the July number of the *Readers' Guide*, published by the Norwich Public Library (post free 2*d.*), is a classified and annotated list of books and articles on the important subject of coal and the nationalisation of coal mines, which should be of much practical use at the present time. The extensive list, making six pages, comprises a representative selection of the principal writings on the subject, and is divided under the following headings: Bibliography, natural history, legislation, general and economic (with a subdivision "Books for Juveniles"), conservation, statistics, reports of Royal Commissions, etc., nationalisation, and mining.

Pulp-making Experiments in Australia.—The Commonwealth Institute of Science and Industry have issued a pamphlet summarising the available information on the suitability of Australian raw materials for making pulp for paper. Results are given of interesting experiments conducted in France on the pulping qualities of Australian eucalyptus, and some results were excellent. If these results are confirmed, the cultivation of forests may prove to be practicable commercially. Experiments made by the Technical School, Perth, showed successful results with karri trees, and it seems possible that spruce could be profitably grown for pulping in the mountainous parts of Victoria and Tasmania.

Co-operation for Small Producers.—A "Smallholders' Guide," intended to give the small producer information about the various forms of co-operation already prevailing in England and Wales, has been published by the Board of Agriculture. It contains many hints on mutual insurance, co-operative purchase of requirements, and co-operation in dairying and in production generally. Suggestions are made for the formation of co-operative societies, and details are given of some of the existing organisations. The booklet is one of a series of "Guides to Smallholders" intended primarily for the use of ex-service men. Nine "Guides" have already been published, and two others are in the press. They are issued gratis and post free to ex-Service men and women intending to settle on the land, on application to the Board of Agriculture, 3, St. James's Square, London, S.W. (1). Copies may be obtained by the general public at the price of 2*d.* each post free.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—August 1, 1919.

No. 3481. AUGUST 8, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,481. VOL. LXVII.

FRIDAY, AUGUST 8, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

GENERAL MEETING.

The Council hereby convene a General Meeting of the Fellows, to be held at the Society's House, John Street, Adelphi, on Monday, August 11th, 1919, at 4 p.m., for the purpose of electing His Royal Highness the Prince of Wales, K.G., a Fellow of the Society.

(By order of the Council),

GEORGE KENNETH MENZIES,
Secretary.

July 29th, 1919.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE SCIENTIFIC PROBLEMS OF ELECTRIC WAVE TELEGRAPHY.

By DR. J. A. FLEMING, F.R.S.,
Professor of Electrical Engineering, University College, London.

Lecture I.—Delivered February 10th, 1919.

ELECTRIC WAVE RADIATION.

Sixteen years ago I had the pleasure of giving a course of Cantor Lectures to the Royal Society of Arts on Hertzian wave telegraphy, in which I endeavoured to explain the elementary principles of this, then new, telegraphy, the achievements of which were beginning to awaken widespread public interest. Since that time immense advances have been made in its practical working and great insight gained into the underlying scientific principles. In this course of lectures I desire to bring to your notice some account of the scientific problems which have since presented themselves for solution and a brief mention of recent advances in connection with modern wireless telegraphy. Broadly speaking, we may divide these problems into three sets—viz., those connected with—

1. The generation and radiation of electric waves.
2. The transmission of these waves over sea and land.
3. The reception and detection of them.

These will occupy our attention in the three lectures of this course.

Since this kind of telegraphic communication is essentially dependent upon the production of electro-magnetic waves of great wave length which can be transmitted through space, it may be well to discuss briefly at the outset their probable nature. By the term "wave motion" is meant any kind of change or disturbance in a medium in which portions of it lying along a radial line perform some sort of cyclical change, such that at successive points the cyclic change is repeated at regular intervals of time. The time in which each cycle of operations is performed is called the "periodic time," and the number of cycles per second is called "the frequency." It is clear that at certain equidistant intervals the cyclic changes will be in step with each other, and this distance is called "the wave length." The cyclic disturbance is propagated with a certain speed, called the "wave velocity," and it is obvious that this is equal to the quotient of wave length by periodic time or to the product of wave length and frequency.

The simplest illustration of such a wave motion is found in the surface waves produced on a lake by throwing a stone into it. The surface particles of the water then rise and fall periodically, and this cyclic motion is performed successively and not simultaneously at points lying on radial lines drawn from the point of initial disturbance.

It is less easy to picture to ourselves the nature of wave motion in a medium. Imagine, however, some widely extended elastic medium,

and think of it as made up of concentric shells like the coats of an onion Two kinds of motion are then possible. Each shell might expand and contract successively, thus causing alternate compression and expansion in adjacent layers, and if these changes take place successively in contiguous layers, a spherical wave of compression and rarefaction would spread out from the central point. Each particle of the medium would move to and fro in a radial direction. This is the nature of a sound wave in air or water of any solid body.

We may, however, consider the successive layers of the medium to slide over each other, moving from side to side or executing a transverse shearing motion with respect to the radial lines. Such a wave is called a "distortional wave." In order that a wave may be propagated it is necessary that the parts of the medium should elastically resist the displacement in question. Thus air, water, and solids resist compression and expansion, and therefore can have created in them compressional waves. Gases and liquids do not resist the sliding motion of one layer over the other, and hence cannot have produced in them distortional waves. These latter can, however, be created in solid bodies which resist shear or transverse displacement and have rigidity. Any change or displacement, whether in bulk or shape, which can be produced in an elastic substance is called a "strain," and the force causing it is called a "stress." The elastic modulus, or the "elasticity," is defined as the quotient of stress by strain. It can be shown that, in the case of wave motion of any kind, the velocity of wave propagation is measured by the square root of the quotient of elasticity by density, where the elasticity considered must be that kind proper to the displacement taking place in the waves in question.

As an illustration we may apply these principles to calculate the speed of a longitudinal wave along a steel wire. Take the case of a steel bar of square sections, and $\frac{1}{4}$ in. in side or $\frac{1}{16}$ square inch in section. A stretching force of 2 tons applied to such a bar would elongate it by 1 part in 400 of length. Hence the stress per square inch is $2 \times 16 \times 2240 = 71{,}680$ lb., and the strain is $\frac{1}{400}$. Therefore, the longitudinal elasticity is $71{,}680 \div \frac{1}{400} = 29{,}000{,}000$ reckoned in inch and pound as units. If we reckon in feet it will be 144 times greater, or 4,176,000,000.

Now 1 cubic foot of steel weighs 550 lb., and since the weight of 1 lb. is 32 absolute units of force, the elasticity in such units is 133,000 million foot-poundals and the density 550. Taking the square root of elasticity by density gives us 15,500 feet per second, which is, therefore, the velocity of a longitudinal wave or sound wave in steel wire. Suppose such a wire stretched from the earth to the moon and the earth end had a sudden "pull" given to it. It would take twenty-two hours before this pull would be felt at the other end in the moon.

Turning, then, to the phenomena of optics, we recall to mind that a physical discovery of great importance was made in the year 1675 A.D. by Olof Roemer, a Danish astronomer, who observed that the eclipses of a certain satellite of Jupiter were not equally spaced out in time, but occurred sometimes earlier and sometimes later, according to the distance of Jupiter from the earth. He drew the correct conclusion that this was due to the finite velocity of light, and his measurements appeared to show that light took about eleven minutes to travel from the sun to the earth. Modern measurements make it about $8\frac{1}{3}$ minutes. Roemer's suggestion, like many other new ideas, was ridiculed and opposed at first, and it was not until after the English astronomer, Dr. James Bradley, had discovered in 1728 the effect, called the "aberration of light," that Roemer's conclusions were accepted. We now know by direct experiment, as well as astronomical observations, that this velocity of light is near to 186,326 miles, or 299,860 kilometres, per second.

It has generally been assumed that this finite velocity of light can only be accounted for by one of two hypotheses, viz., that light must either be some kind of substance or particles projected through space by luminous bodies, or else that it must be a wave motion created in a universal medium or æther.

Of late years the doctrine of Relativity has, however, provided new but rather abstruse possible explanations which take us into very deep waters regarding fundamental ideas of Space and Time.

I shall not, however, attempt the task of expounding, even in outline, these modern mathematical concepts. As a working hypothesis and means of connecting facts, we find a good basis for explanations in the postulation of a non-gravitative space-filling æther, in which waves of a certain kind can be created. For a large number of optical and electrical phenomena, this classical hypothesis still suffices to provide consistent and intelligible explanation.

The true authorship of this undulatory theory of light must be ascribed to Robert Hooke,

one of the founders of the Royal Society, and at one time its secretary. In 1667 he clearly outlined this theory in his book "Micrographia," and asserted that light was a very rapid vibration in a universal medium. As is well known, Sir Isaac Newton was led to reject this hypothesis on the ground that such a wave motion would spread round opaque objects, just as a sound wave does, and hence that sharp shadows could not be formed. As a matter of fact, such diffraction does occur, but its degree is determined by the ratio of the wave length to the size of the object, and in Newton's time the length of light waves had not been measured, nor their extreme smallness realised. Again, Newton was influenced by the then recently discovered fact that a ray of light which had passed through certain crystals and been polarised, as it is now termed, had different qualities on two sides, so that it differed from an ordinary ray of light, in the same manner that a long flat or rectangular-sectioned rod differs from a circular-sectioned rod. The first advocates of the undulatory theory of light assumed that the æther vibrations, like those of a sound wave in air, were longitudinal, and, if so, it is obvious there could not possibly be any asymmetry on the two sides of a ray of light. Hence Newton adopted the view that light was due to certain luminous corpuscles shot out from luminous bodies. To explain the refraction of light on this theory, it was necessary to assume that light travelled quicker in dense transparent bodies like glass or water than in air; but this is opposed to facts. This corpuscular theory held sway, however, for about a century, but was then replaced by a new type of undulatory theory, based on discoveries due to Augustin Fresnel and Thomas Young.

The important fact was by them discovered that two rays of light originating in the same source, but reaching a distant point by paths slightly different in length, may destroy one another. If light is a substance, it is impossible to explain how light added to light can produce darkness. But if light is an undulation, then we know, from effects seen with surface waves on water, that the depressions in one wave train may happen to coincide with the elevations in another wave, and so the two may neutralise each other. This effect, called "interference," is found to exist in the case of aerial sound waves as well as in the case of tidal waves on water. Again, the actual measurement of the velocity of light in air and water showed that it was less and not greater in the latter case. Hence, at the beginning of the nineteenth century, the undulatory theory began to be generally accepted. Nevertheless, there remained the difficulty of accounting for the asymmetry of a polarised ray. This was only conquered when Fresnel and Young adopted the bold hypothesis that the ætherial vibrations which constitute light are transverse to the direction of ray propagation. But this seemed to require that the undulating medium must possess rigidity of form, or elastic resistance to shearing. We know of no material solid body which possesses this kind of elasticity without possessing also elasticity of volume or resistance to compression.

In the case of every known material elastic solid, a shock created in the interior gives rise to two sets of waves. One set arises from the elastic resistance to compression or extension, which, in fact, are sound or acoustic waves, and the other is due to the elastic resistance to shearing or distortion. These waves travel with different velocities. In the case of the earth, any deep-seated earthquake shock gives rise to two earthquake waves, viz., compressional waves, which travel at the rate of about ten kilometres or six and a quarter miles per second, and distortional waves, which travel at about half that speed, viz., five kilometres or three and one-eighth miles per second.* No one has ever found a solid which will not transmit sound waves through it, yet which will transmit waves of distortion or shearing.

On the other hand, no one has discovered any phenomena which indicate that the æther or undulating medium of optics, can have any compressional wave made in it.

We are then brought face to face with certain difficulties. The phenomena of optics seem best explicable on the assumption that light

* This velocity of the distortional wave shows that the earth as a whole is more rigid than if it were a ball of steel. For since the distortional wave velocity is ·5 kilometres per second $= \frac{1}{2} \times 10^6$ centimetres/sec. and is equal to $\sqrt{\frac{e}{d}}$ where e is "simple rigidity" and d = density = 5·6, we have $e = \frac{5 \cdot 6}{4} \times 10^{12} = 14 \times 10^{11}$ in centimetre, gramme, second units. But in the C.G.S. system the "simple rigidity" of steel is only 8×10^{11}. Lord Kelvin inferred from tidal phenomena that this must be the case. Supposing then the æther had the same rigidity as steel, viz. 8×10^{11}; since the velocity of waves in æther is 3×10^{10} centimetres per second, it is clear that the density must be $\frac{8}{9} \times 10^{-9}$ or, one hundred thousandth part of the density of hydrogen gas at 0° C. and 760 mm. to enable waves in it to travel with the stated velocity. A substance with the rigidity of steel and density of 1/100,000th of hydrogen is to say the least a remarkable combination.

consists in undulations. But this necessitates the hypothesis of some universal medium which can undulate. Furthermore, optical effects demand the assumption that these undulations are transverse to the ray direction, and there are no effects which give ground for the assumption of longitudinal vibrations. Hence the æther must have very peculiar properties. It must have rigidity or elasticity of form like a material solid and resist shearing, and yet be either perfectly incompressible or have no elastic resistance to such compression. The endeavour to account for these abnormal qualities by various structural hypotheses has given rise to a large number of theories of the constitution of the æther. This was a matter which immensely interested the late Lord Kelvin, and to the end of his life he gave to its consideration the closest attention. Our time, however, will not permit me to sketch even in briefest outline these various mechanical theories of æther structure, but we must pass on at once to consider the point of view from which Clerk-Maxwell approached the subject.

The phenomena of electricity and magnetism had, from the beginning of the nineteenth century, very strongly suggested to many minds such as those of Ampère, Faraday, and Joseph Henry, that there must be an electromagnetic medium in space through and by which such actions at a distance as electrostatic and electrokinetic induction take place. An electric current in one wire, when it starts or stops, can produce in another parallel but distant wire an induced or secondary current. But now, unless we make the bold assumption of action at a distance, which Newton thought impossible for any competent thinker, we must assume the existence of an electromagnetic medium or æther to account for such distance actions. But, as Maxwell observed, it is clearly unphilosophical to postulate the existence of more than one æther until we have proved that one is not enough. Moreover, Maxwell recognised that we know nothing as yet about the mechanical structure of the æther or of the nature of its elasticity or inertia. Hence he abandoned the attempt to make any hypotheses but approached the subject from an entirely new point of view. We know that in electric and magnetic phenomena we have to do with two states or conditions which can be produced in and through insulators and also in a most perfect vacuum—viz. an electric field and a magnetic field. An electric field exists in proximity to electrified bodies and a magnetic field near magnets or conductors carrying electric currents. We ascribe these states to two agencies or causes we call "electric force" and "magnetic force," and the states themselves are called "electric strain" or "displacement" and "magnetic flux." Moreover, every insulator, even a most perfect vacuum, possesses two intrinsic qualities in virtue of which electric force (E) produces electric strain or displacement (D), and magnetic force (H) produces magnetic flux (B), and these are called the di-electric power (κ) and permeability (μ). This is quite analogous to the mechanical qualities in virtue of which mechanical stress produces mechanical strain and moving force produces acceleration in matter. We call the ratio of stress to strain elasticity, and of moving force to acceleration the mass or density. Moreover, just as there are two forms of energy in mechanics, so-called potential and kinetic, so also we have two forms of energy in electro-magnetism—viz. electrostatic, due to electric charge at rest, and electro-magnetic, due to electric current or electric charge in motion.

Again, there is a further relation between the electric and magnetic quantities expressed: (1) By Faraday's law of induction—namely, that the time rate of change of magnetic flux through an electric circuit is the measure of the electromotive force created in it; and (2) by Ampère's principle, that the line integral of magnetic force round a circuit is a measure of the total electric current through the circuit. These two principles had long been familiar to electricians in connection with conductive or metallic circuits, but Maxwell made the illuminating suggestion that they were equally true for di-electrics or insulating bodies, and true also for empty space, provided that rate of change of electric strain or displacement is regarded as an electric current. Maxwell then proceeded to give mathematical expression to these four relations of electric and magnetic force and flux, and found that this led to an equation called a differential equation, which had exactly the same form as the differential equation for wave motion in a medium having elasticity of form but no compressibility. The equation, moreover, expressed the fact that the wave motion in the medium would be propagated with a velocity inversely as the square root of the product of the permeability and the di-electric constant.

Now it so happens that this product—viz. $1/\sqrt{\kappa\mu}$—can be determined by purely electromagnetic measurements, and for air it is close

to 3×10^{10} with centimetres and seconds as units. But this is the velocity of light in air, and hence Maxwell's equations proved not only that electric and magnetic forces are propagated through space as waves, but that the velocity of these waves is identical with that of light, and that the known qualities of the medium in which this propagation takes place are just those which must be assumed in the optical æther.

Maxwell made at once the important deduction that light waves are really electro-magnetic waves, and that the luminiferous and electro-magnetic æthers are one and the same.

This theory of light was enunciated by Maxwell in 1865, but strikingly novel though it was it did not command much general attention owing to the fact that no means had been devised of producing electro-magnetic waves other than those which constitute light and radiant heat. G. F. Fitzgerald had, indeed, suggested that it might be done by the oscillatory discharge of a Leyden jar, but he had not carried his suggestion to the point of experimental proof.

Hertz, however, took up the subject at the suggestion of Von Helmholtz in Germany, and in 1887 had devised a practical method of creating Maxwell's electro-magnetic waves by the appliance since called a "Hertz oscillator." This consisted of two rods placed in one line, the ends in close proximity being provided with spark balls and the outer ends with flat plates. Such an arrangement forms a kind of Leyden jar, and when the two plates are charged with opposite electricities + and − by means of an induction coil and the pressure raised until a spark discharge occurs, the result is a brief oscillatory discharge which creates an electro-magnetic wave. To understand the mechanism of this wave production we must bear in mind that there are a number of phenomena which prove that electricity is atomic in structure like matter, and the agency we call negative or resinous electricity consists of corpuscles or particles called electrons, which in size are vastly smaller than any chemical atom. These electrons are centres from which proceed out in radial directions lines of electric force. According to the views of Faraday, which have been given precise form by Sir J. J. Thomson, these lines of electric force are not merely mathematical concepts, but have probably a physical existence as lines of strain, twist, or rotation of some kind in the æther which radiate out from the electron. But it has been proved by actual experiments, first made by Rowland, and confirmed by many others, that a moving charge of electricity creates a magnetic field distributed in circles round it. Thomson and Heaviside have proved that the result of moving a line of electric force sideways or parallel to itself is to create a line of magnetic force which is at right angles both to the line of electric force and to its direction of motion. Also it has been proved that lines of electric force behave like elastic threads and tend to shorten themselves. In fact, the attraction between two oppositely charged conductors is merely due to the effort of the lines of electric force passing from one to the other to shorten themselves. Again, these lines of electric force possess a quality which resembles inertia, and is in fact, the inertia of the æther.

Accordingly, a line of electric force has the two qualities of elasticity and inertia which are requisite to enable waves of distortion to be propagated along it. If then we suppose one end of a line of electric force terminating on an electron to be given a jerk by a sudden transverse motion of the electron, the result will be to propagate along the line a "kink," like that on a rope when one end is jerked. The present-day electronic theory of electricity assumes that the substances we call good conductors of electricity, like metals, are so because there are present in them, in between the chemical atoms composing them, free electrons. These electrons are moving to and fro, and jumping from atom to atom indiscriminately, and the temperature of the body is determined in part by the energy of this irregular electronic motion.

If, however, an electromotive force acts on these free electrons, it gives them a drift in one direction, which is superimposed upon the thermal motion, just as a swarm of gnats in irregular to and fro motion might be drifted down a street, as a whole, by a gentle breeze.

This uniform drift of electrons constitutes an electric current. If the current is alternating, then the electrons in the wire merely jump to and fro between certain limits. The result of this is to give a jerk to the ends of the lines of force proceeding from the electron, which creates waves, which travel outwards along the line, and may be regarded as similar to the wave which can be propagated along a rope when we give one end a jerk.

If then we have multitudes of electrons in a metal rod or wire, executing this to and fro dance in step with each other, it admits of easy

proof that the result will be to send out from the wire, in radial directions, closed loops of electric force having their planes in the plane of the wave. As these loops move outwards, they are accompanied by lines of magnetic force, which are arranged in circles round the rod, with planes perpendicular to it. These circles must be considered to expand outwards, like the ripples on a pond when a stone is thrown into it.

The conjoint movement of lines of electric force and magnetic force at rigid angles to each other, and to the direction of their motion, constitutes an electro-magnetic pulse or wave.

If the electrons merely made one jump to and fro, the result would be to send out one single loop of electric force, accompanied by two rings of magnetic force oppositely directed. If the electrons keep up their vibration steadily, the result is to radiate persistently an electro-magnetic wave.

In accordance with Maxwell's theory, such electro-magnetic radiation is identical in nature with light; but it cannot affect our eyes, because the retina of the eye is only sensitive to ætherial vibrations, which have a frequency between about 400 billion and 700 billion per second. The width of the loop of electric force is called half a wave length, and in the case of light the complete wave length is of the order of $\frac{1}{50000}$ part of an inch in length. In the case of electric waves created by electric oscillations in wires or rods, the wave length may range from a few inches, or even centimetres, up to five or ten miles. By certain mathematical processes it is possible to delineate the exact form of these closed loops of electric force radiated from a Hertzian oscillator, and to show their successive forms and positions as the oscillations proceed.* By photographing them on a film, and projecting the image of the film on a screen by a cinema lantern, it is possible to see the whole process in working operation. Hertz succeeded by his oscillator in creating electro-magnetic waves of a few feet or yards in wave length, and detecting their presence by an appliance called a ring resonator, and he demonstrated that such waves can be reflected and refracted like light and quasi-optical experiments performed with them. Although such electro-optic phenomena interested extremely scientific men, as giving objective proof of Maxwell's electro-magnetic waves, yet the general public were not concerned with the subject until Senatore Marconi, twenty-two or twenty-three years ago, made a new departure of great importance. He showed that if a very large Hertzian oscillator is constructed of a wire or wires, 150 ft. or so in length, held vertically, and with the lower end separated by a pair of spark balls from a metal plate sunk in the earth, electric oscillations created on this oscillator will send out electro-magnetic waves of 1,000 ft. wave length or more, capable of travelling long distances over sea or land surface. He invented specially sensitive means for detecting these waves, and also adopted means for employing them to signal messages in Morse Code, thus giving us a new wireless telegraphy of immense practical value.

From and after that time, inventors and scientists, all the world over, have been earnestly engaged in developing the details, and making improvements in this radio-telegraphy.

Considering next the transmitting part of the arrangement, the equivalent of the Hertzian oscillator is this so-called aerial wire or antenna. In practical work it takes many forms. On board ship it is generally a group of wires stretched horizontally from mast to mast, sustained at the ends by insulators, and a group of vertical wires coming down from the others, thus forming a T-shaped antenna.

On land it generally takes the form of a vertical metal tower, insulated at the lower end, and from the top a number of extended wires, like the ribs of an umbrella, thus forming an umbrella-antenna. In the other cases, a number of wires are sustained in a horizontal position by masts of wood or metal, and from one end vertical wires come down, this making an inverted ˥ or L-shaped aerial. This latter type was invented by Senatore Marconi, and it has the peculiar property of projecting its electric waves most energetically in the opposite direction to that towards which the free horizontal end points.

The range of the waves sent out increases with the height of the aerial wire, and in modern long distance stations the masts or towers elevating the wire have a height of 400 to 600 ft.

* In the case of a Hertzian or rod oscillator, the electric force in the external space arises partly from the rapid changes of current in the rod, and partly from the free electric charges which make their appearance alternately at the outer ends of the rods. The former is said to be due to the vector potential of the current, and the latter to the scalar potential of the charges. The effect of both these variations is to create closed loops of electric force which move away from the rod in radial planes with the velocity of light. The total electric force at external points depends on the time rate of decrease of the vector potential and on the space rate of decrease of the scalar potential.

or more. In Paris the Eiffel Tower, which is 1,000 ft. high, is used as the antenna support for one station. In some long distance stations the aerial consists of a network of wire, called a capacity area, which is upheld by several masts (three or four) at a height of several hundred feet above the ground, and this network is connected by vertical wires, with a similar network sunk in the earth. In the United States large naval radio stations, erected at Darien and in Honolulu and the Philippine Islands, the capacity areas are networks of triangular shape, 1,100 ft. inside, upheld by three steel towers 500 ft. high. The German radio-station at Nauen, near Berlin, which has been so active during the war, is an umbrella antenna 900 ft. in height, and corresponds with a similar station at Tuckerton in the United States. The large Marconi station at Carnarvon in North Wales, is a directive antenna. The horizontal wires are 1,200 yards long, and are supported at a height of 400 ft. above the ground by ten steel masts.

In all these cases there is a counterpoise or underground network of wires, which forms, so to speak, the other half of the Hertzian oscillator.

In modern aerials the spark balls are not placed between the wires connecting the overhead elevated capacity and the underground network, but there is a coil of a few turns of insulated wire in their place called the primary circuit of an oscillation transformer, and in this coil are set up high frequency oscillations by induction from another oscillation circuit comprising a condenser and spark gap. These oscillations are generated in intermittent groups. On the other hand, they may be so-called undamped oscillations generated by some form of high frequency alternator or else by an arc-generator of the Poulsen-Duddell type. The great majority of small stations, however, are worked on the damped oscillations, or so-called spark system, in which a large condenser is charged by high tension transformers and then discharged across a spark gap with electric oscillations. These oscillations pass through a coil of wire in close proximity to the coil in the circuit of the antenna and thus induce very powerful high frequency currents in the aerial wire. These currents run up to 100 or 500 amperes in mean-square value, and produce exceedingly high voltages at the free top ends of the aerial wires. The energy given to the antenna alternates in form from electrostatic to current energy, and at each spark there may be a hundred or more of such powerful decadent oscillations in the aerial wires.

The manner in which these create the electric waves is as follows: At the moment when the energy is all electrostatic the elevated capacity area is charged to a very high potential—it may be several million volts—and hence from all parts of the aerial lines of electric force proceed in curved paths to the earth or earth plate. At the moment when the energy passes into the current or electrokinetic form this electric charge disappears, and in its place we have a strong electric current flowing to or from the elevated capacity in the vertical wires. This creates a magnetic field distributed in circular paths round the aerial At each complete cycle of such changes semi-loops of lines of electric force fly away in all directions from the aerial, the ends of these loops resting on the earth, and near the earth's surface being nearly perpendicular to it. The plane of these semi-loops is vertical through the aerial. The plane of the circular lines of magnetic force is parallel to the earth's surface, so that at any point the electric and magnetic forces are perpendicular to each other and to the direction of their motion. These lines flit outwards with the velocity of light, and constitute an electro-magnetic wave. The distance between two points of like directed maximum force is called the wave length, and in large stations is of the order of 20,000 ft. to 50,000 ft., but in ship stations about 1,000 ft. to 2,000 ft. or 3,000 ft. At each condenser discharge a certain quantity of energy is conveyed to the aerial, and this is partly dissipated as heat in the aerial wires and heat in the earth plate and heat in the soil or sea round the base of the aerial. Part of the energy is radiated as electric waves from the antenna. The efficiency of the antenna is measured by the percentage of the total power given to it, which is radiated in the form of electric waves. The aerial is, in fact, a lighthouse which emits a great flash of radiation invisible to our eyes at each condenser discharge. There is, therefore, much room for expert knowledge in the design of aerials. The great object is to reduce as much as possible the energy wasted as heat in the aerial wires and in the earth round the aerial.

By applying an important theorem in electromagnetism, due to the late Professor J. H. Poynting, we can calculate the power radiated by a vertical wire antenna of a height h radiating electro-magnetic waves of length λ, when a current of a amperes exists in the base of the wire. For a plain single-wire antenna this

power in watts is expressed by the formula,

$$W = 640 \frac{h^2}{\lambda^2} a^2,$$

whilst for a flat-top or T antenna it is given by

$$W = 1600 \frac{h^2}{\lambda^2} a^2.$$

In any case it is the product of the square of the antenna oscillation current at the base and a quantity called the radiation resistance of the antenna. This resistance may be expressed, therefore, in ohms. In addition to the power radiated a certain amount is dissipated as heat in the aerial wire and in the earth plate and surrounding earth, and this is measured by the product of the square of the antenna current and a certain resistance, expressed in ohms, called the frictional resistance of the aerial. An important quality of an aerial is that it should radiate as much of the imparted power as possible in the form of waves. Although various methods have been suggested for measuring the radiation and frictional resistances of aerials of various types, none are very satisfactory. In fact, one of the yet unsolved practical problems of radio-telegraphy is to find means for quickly and accurately measuring the total power imparted to an aerial and the total quantity of it radiated as effective signalling waves, and hence the antenna efficiency. Another important quality of an antenna is its degree of damping, which means whether oscillations set up in it subside slowly, in which case they are said to be feebly damped, or quickly, when they are highly damped. The ratio of the amplitude of two successive like-directed oscillations is called the damping factor or coefficient. This damping is caused by dissipation of energy, and may be due to radiation or to frictional resistance. It is important that the oscillations in each train or group should not die away too quickly. There ought at least to be fifty to one hundred free oscillations when a sudden electric impulse is applied to the aerial before the electrical vibrations cease. We shall refer to this matter again in connection with receiving arrangements. Certain types of antenna, such as the umbrella antenna, radiate their stored power more slowly than simple straight wire antennæ, and hence have a less damping factor.

The high frequency alternators, such as those of Alexanderson and Goldschmidt, create undamped waves or persistent oscillations, and much controversy has taken place over the relative advantages of damped and undamped waves in radio-telegraphy. By some radio-telegraphists the view is held that the undamped waves are absorbed or attenuated less than the damp waves in passing over the earth. We shall consider this point in our next lecture. The form and construction of the aerial or antenna exercises a most important influence on the manner in which the electric radiation is sent out, and on the nature of it.

A simple vertical wire has perfect symmetry of radiation, but on account of its high radiative power, it sends out the energy communicated to it at each spark discharge in a very rapidly decadent or damped train of waves. As we shall see in the third lecture, this is a disadvantage from the point of view of selectivity in the receiving apparatus. Hence highly damped antennæ should not be used.

We can control this, and make the aerial radiate less well by bending down part of the wire so as to make a partly closed antennæ. If, for instance, the aerial has a part vertical and a part horizontal, it has less radiative power than if it were all vertical. But it also then has an unsymmetrical radiation. It radiates better in the opposite direction to which the free end points than in the same direction. Hence this directive aerial of Marconi has very great uses. If we take a number of such vertical aerials, and bend down the tops in radial fashion, we obtain an umbrella aerial which has a less damping than a plain vertical, but it radiates symmetrically. Accordingly, it is a much used type.

The type of aerial which consists of some form of capacity, such as a metal network, supported at a great height above the ground, and connected by vertical wires with the oscillation coil at the earth's surface, has the advantage that the strong currents, which are at the base of the aerial, are vertical to the earth, and, therefore, do not tend to create induced currents in it which would dissipate energy.

It is of great importance that the lower parts of the aerial wire, in which extremely powerful high frequency currents exist, should not be near any metal, brickwork walls, or moist wood, or anything else in which they can cause induced currents, as this would tend to damp the oscillations and drain away energy from the aerial wire. Also, all the lower parts of the aerial wire should be perpendicular to the earth, and not carried parallel to it unless at a great height above the earth. It is a curious and valuable property of the plain vertical aerial, that it radiates its energy chiefly in a direction parallel to the earth, which is what is required generally. Now, however, that radio-communication with

aeroplanes and airships is so important, it becomes interesting to inquire how we can control the radiation, so as to direct it upwards at any inclination.

This has been mathematically discussed by Dr. Van der Pol, jun., in a paper "On the Wave-Lengths and Radiation of Loaded Antennæ." He has shown that if large capacity is put at the top of an aerial, so as to form a current node at the centre, the most energetic radiation will be directed in an upward inclined direction; the polar curve of radiation then resembling a pair of butterfly's wings.

A few words must be said in conclusion on the lay-out and design of large radio-stations.

If power can be obtained from a near or distant electric power-station, then it is most convenient to take advantage of this and convert it to mechanical power by electric motors. This is the case at the large Marconi station at Carnarvon.

If, on the other hand, power must be locally generated, then the arrangements are simply those of an electric lighting or power station. Boilers, engines, and condensing plants; coal supply and means for handling fuel and water, as well as the duplication of plant, to secure from interruption, are put in, but the engines drive high frequency alternators instead of low.

If the station is on the spark system, the alternators would have a frequency of 300 to 500, and their voltage would be raised by oil-insulated transformers to 20,000 or 30,000 volts.

These latter would then charge a bank of condensers, across the terminals of which is some form of rotating spark gap, in series with the primary of the oscillation transformer.

If the station is an undamped wave station then entire high frequency alternators would be put in, giving a frequency of not less than 50,000 volts. This may be obtained either by a Goldschmidt frequency raising alternator, or by the use of an induction alternator, giving, say, a frequency of 15,000 or 20,000, associated with frequency raising transformers.

Senatore Marconi has invented a method of producing practically undamped waves by the employment of several rotating disk dischargers, each of which causes successively the discharge of a large condenser in such fashion that the oscillations produced by one disk begin just at the moment those produced by another end. Thus slightly damped trains of oscillations can be induced in the aerial so that the head of one train is in contact with the tail of the preceding one.

The antenna supports form an important element in the design. These may be wooden or steel lattice towers, or else steel masts built up in sections as made by the Marconi Company. The height of these, in large stations, varies from 250 ft. to 600 ft. or more. For very long distance working high antenna masts are necessary.

Before long the world will be covered with high-power radio-stations, and as far as can be judged at present the indications are that the radio-telegraphy of the future will chiefly be conducted by means of undamped or continuous waves produced by various methods.

BEAD-MAKING AT MURANO AND VENICE.

Glass-making in Venice is of remote antiquity. By a law of November 8th, 1291, the authorities of Venice, to avoid the risk of fire, ordered the glass-making industry to be transferred to the adjacent island of Murano, referring in the decree to the "ancient traditions of the populace there dedicated exclusively to glass-making." Ever since, Murano has been the most important centre for handmade glass and glass-bead manufacture in the world.

In recent years the manufacture of certain kinds of handmade beads that must be worked and ornamented individually over the blowpipe, and certain processes in the manufacture of machine-made beads, such as stringing and the polishing and glazing of some types, have been again transferred to Venice. Most of the loose stringing of beads is carried on by cottage labour in Venice, and the processes for the manufacture of bead articles, such as purses, curtains, flowers, and design work, are domiciled again in Venice, leaving in Murano the glass and bead foundries.

The island of Murano lies less than a mile distant over the lagoon north of the city of Venice. Its population is chiefly engaged in the various glass industries, including bead-making.

Until 1896 there were a number of competing companies engaged in bead-making at Murano, but at that time eleven companies consolidated, forming the Società Veneziana Per l'Industria delle Conterie, whose paid-up capital stock is now 4,500,000 lire (£180,000 at par). This company enjoys a complete monopoly of the bead-making industry, has been very prosperous, and does an exporting business on a great scale, shipping to Africa, Oceania, Asia, including India, Europe, and the Americas. It makes the beads that are used as money by certain tribes in the Congo and in West Africa, and ships many thousands of tons of bead ornaments to the savage as well as the civilised nations of the world. The offices of the company are in a magnificent old palace at Murano, the Palazzo Trevisan, which

boasts frescoes by Tiepolo. Near by are the foundries and factories, covering many acres of ground. Before the outbreak of the great war this company kept in storage more than 2,000,000 kilos (4,409,245 lb.) of manufactured beads. At the present time the quantity in stock is very much less, and production has greatly decreased, owing to difficulty in securing fuel and raw material, and to the immense rise in the cost of these requisites.

According to an exhaustive report on the bead-making industry at Murano and Venice, furnished to his Government by the United States Consul at Venice, the first process in the manufacture of beads is making glass compounded of soda, sand, and various minerals according to the colour desired. The yellows and oranges have a large admixture of lead. It is introduced in the form of an oxide known as "minio." This minio is, it is believed, oxide of lead, and comes in several grades according to the vividness of the colour, ranging from deep orange to red.

The fondant for ordinary types of beads had formerly a base of Egyptian natron (native sodium carbonate). Nitrate of soda from Chile and crude nitre (saltpetre), refined carbonates of soda, sulphate of soda, refined nitre, potash, cryolite (a fluoride of sodium and aluminium produced in Greenland, used for obtaining soda and alumina), and especially the highly refined Solvay soda used as a solvent for sand (formerly imported from France, now made also in Italy), figure in the fondants required for the higher types of beads.

The colouring materials are all mineral, including in recent years various oxides unknown to the glassmakers of antiquity, especially oxides of cobalt, chromium, and uranium. The more important colouring materials are minio, compounds of manganese, copper (from which a great variety of colours are obtained), iron, zinc, arsenic, antimony, silver, gold, and zaffara (a sort of mixture of which cobalt is the base, used for tinting glass blue).

Cobalt in its various combinations gives deep shades of blue and was a colouring agent known to the Egyptians, as was also copper. Silver was used by the ancients to give a yellow-gold colour, but the master glassmakers now know how to obtain the same shades without the use of silver. The first to obtain a formula was a certain Giovanni Giacomuzzi. This maker also tried to produce the deep ruby or pigeon-blood colour for which gold is the only successful colouring agent, and marketable shades have been produced, but none that compare with the ruby glass of the old makers which was coloured with gold. This glass is known as rubino. Most of the secrets of the trade lie in the colour formulas, which naturally are not divulged. New colours and shades and combinations are constantly being formed, so that Venetian beads run through the entire prismatic scale.

The processes of bead-making are often said to be three, to wit, making the glass, making the canes, making the beads out of the canes; but so simple a classification is not instructive. A better division is obtained by following the processes of the industry itself as seen at Murano:—

(1) Compounding the materials; (2) fusing the materials into the fondant or molten glass; (3) cupping the fondant to prepare the orifice that will run through every cane and every bead; (4) pulling the fondant into long hollow tubes; (5) cutting the tubes into canes of about one yard in length; (6) sorting the canes according to diameter; (7) clipping the assorted canes into bead lengths and fanning out the powdered glass; (8) filling the orifices of the sharp-edged beads with a composition of charcoal and lime, mixing the beads thus filled with a quantity of sea sand, re-fusing in revolving crucibles to eliminate the sharp edges and round the beads, and cooling; (9) fanning out the sea sand and mechanically sorting the beads for size; (10) mechanical sorting for perfect perforation; (11) in some cases polishing or elucidation; (12) and (13) stringing or mechanical threading on fine metal wires; (14) sorting strung beads for colour; (15) packing for shipment.

This list of processes will cover the manufacture of all the smaller beads produced in bulk, and, in fact, of all one-colour beads not handmade. Taking up these processes in their order, it may be noted that all except the first are subject to inspection.

(1) Compounding the materials. This is done according to formulas more or less secret out of the materials already enumerated, and others such as carbonate of lime, cream of tartar, and various minerals. At present the basement of the immense plant of the Società Veneziana is used as a storage room where soda, potash, sand from Fontainebleau, minio, and other minerals for composing the fondant are kept.

(2) The glass is fused into the molten mass or fondant in immense crucibles, lined with fireproof tiling and clay, some of which hold five and six tons of molten glass. The degree of heat obtained varies from 1000° to 1600° C., as the materials must be exposed to a heat of 1000° before they fuse properly. The immense pots or crucibles are covered over, lined with fire clay, and have orifices or port-holes through which can be seen the glow of the melted glass.

(3) About the crucible are workmen with great tubes of iron like a section of gas-pipe 12 or 15 feet in length, called ferri da canne. This they dip through the port-holes into the molten fondant and take out a doughlike mass, which is then pounded on metal tables or anvils until it begins to change in colour from white to red. Roughly rounded by this process, the doughlike mass on the end of the rod is then opened by another workman with an instrument called a borsetta, that appears to be a giant pair of spring pincers, and the fondant is scooped and pressed out as if it were a dumpling being prepared for an apple.

This scooping out creates the orifice or hole, which ordinarily remains through all other processes until the beads are finished and complete. This cupped mass is again thrust into the oven and heated to white heat and almost the consistency of glue without being allowed to collapse or lose its cupped form. It is again taken out of the crucible, and another workman, provided with an iron rod having a broad, blunt end, presses that end against the top of the fondant cup, to which the heat causes it to adhere.

(4) As soon as the second rod adheres the two men walk away from each other, pulling out the melted glass between them. Cross-ties are laid at intervals over the floor, and on these the rope of glass is supported. So ductile is the fondant that a mass the size of a loaf of bread can be stretched for a distance of about 300 yards. Even when the fondant is pulled out to the thinness of a cambric needle it remains a pipe or tube, the bowl of the cup growing ever smaller but always remaining hollow. This fact renders bead-making in bulk possible.

(5) As it cools, this tube or pipe (which often resembles an unbroken filament of vermicelli) changes from white to red and from red to the permanent colour given it by its mineral colouring matter. The size of this tube will depend on three things:—

(*a*) The fineness and character of the materials of which it is composed, which will affect its ductility, especially the quality and quantity of soda used.

(*b*) The size of the cupped mass drawn out. A smaller mass makes a finer and thinner tube.

(*c*) The speed at which the two men walk away from each other in stringing out the molten mass. If they walk rapidly the tube will be smaller and thinner.

As large beads are made in precisely the same way as small ones the diameter of the beads will depend entirely on these three things, and especially on the last two, for out of the same fondant tubes of all sizes can be made. These tubes are, when cold, cut or broken into lengths of about one yard. These lengths are called "canne" (canes or reeds) and resemble straws or bamboo rods without joints; and these canne are the material out of which the beads are made. In similar fashion rods that are not hollow canes can be made by merely omitting to make the cup in the fondant.

(6) The canes are sorted into sheaves of the same size. This work is done by women and often by quite young girls, who work by the sense of touch, rapidly dividing canes that are apparently all of the same diameter into different groups between the fingers.

(7) The sheaves are then taken to the clipping machines, which resemble little guillotines. On a flat trough the canes, placed side by side, pass automatically (but guided by hand) under the little guillotine blade that, by the revolution of an electrically-driven wheel, clips the canes into bits by biting off the ends. The length of these bits is about equal to the diameter of the cane. These clipped cross sections have sharp edges. The powdered glass produced by the clipping is sifted and fanned out, and the raw-edged beads are ready for rounding and finishing.

(8) The holes in the raw beads are filled with a composition of charcoal and ordinary lime, after which the beads are intermixed in four or five times their weight of ordinary beach sand from the Adriatic, and the sand and stuffed beads are put into an egg-shaped, covered crucible that revolves on an axis, tilted at about the same angle of inclination as the globe. This crucible revolves in the heart of a gas-fed furnace at about 400° of heat. The charcoal is consumed, the lime vanishes after having served to "fix" the aperture, the edges of the beads become smooth and rounded, the sand grinds and polishes them, and at the same time keeps them from coalescing with each other, and, finally, sand and beads together are dumped out into large shallow pans to cool.

(9) When cold the sand is sifted and fanned away in a series of large, covered, wooden ventilators, and the beads, clean and polished, pass through a funnel or hopper into a series of rocking cradles placed one above the other in a series of eight. The floors of these cradles are sieves with graduated orifices or mesh bottoms, and from these cradles the beads, neatly assorted as to size, pass through little hoppers into baskets set to receive them. Beads of the same colour but of many different sizes are thus automatically assorted as to size. (Assortment as to colour is first made by hand while the beads are still in the cane.)

(10) For the smaller varieties of beads still another sorting is necessary to determine if the holes have been perfectly preserved. For this purpose a cylinder about 15 inches in diameter, covered with thin wire filaments (like a wire brush), revolves over a tray of beads, and the filaments catch the beads that have holes in them, lifting them over, on the principle of a waterwheel scooping up water, and dropping them on the other side through a hopper into a box. The bead is now complete, sorted as to colour, tested as to size and perforation, associated with its fellows and equals, and ready for stringing or for shipping unstrung. This finishes the necessary processes for making one-colour beads.

The necessity of a machine to sort the beads for perforation to detect and discard the imperfectly perforated beads was very great. In 1894 it was possible to make the ordinary small beads for about 70 centesimi per kilo (100 centesimi = 1 lira; kilo = 2·2046 lb.). The threading was done by women, as at present, using a handful of needles (24 to 30) at a time and threading very rapidly. For the very small beads the string was about 10 inches long and for the larger beads about 18 inches long. A bundle consisted then of 480 strings, and a good worker could string 10 bundles per day at 12 centesimi per bundle.

There was a constant controversy between the women and the companies because out of every 100 kilos the former used to bring back 20 kilos, or one-fifth, claiming that they could not be strung—meaning that they could not be strung rapidly as the orifices were small or faulty, and as the woman worked by the piece they interfered with her speed and diminished her pay. Only about 5 per cent., or 5 kilos out of 100, were totally lacking in perforation. So the makers had a grievance as well as the women, as such beads had to be remelted and remade, and for this purpose had a value of only 5 centesimi per kilo, and the makers were losing about 9 lire per 100 kilos on 15 kilos of beads that could have been strung but not rapidly.

Cavaliere Salvatore Arbib, one of the manufacturers, conceived the idea of the sorting drum with the wire teeth, and the machine, called a "tamburo," was made by a British firm. The teeth or threads of the sorting machines may be of various diameters, so that the beads rejected by a coarse-toothed machine may be picked up by a finer toothed tamburo. This machine was perfected in 1894. The first threading machine to thread the beads on fine wire was made by the same firm in the same year for the same man. The total cost of the experiments and the making of the two machines was about £5,000 sterling.

To return to the processes.

(11) Certain one-colour beads for America have the surfaces slightly ground by contact with emery paste or other grinding material, or even sawdust. This process takes place outside the Murano factory and usually in Venice. It is called lucidation (lucidazione).

(12) Certain beads are then strung by special machinery on thin wire filaments. The wires are suspended in brass tubes and the projecting curved end of the wire picks up beads from a revolving basin which forces them against the end of the wire. These wire-strung beads are mostly exported to France for use in making the coarser grades of artificial flowers for funeral wreaths.

(13) All small beads are ordinarily strung by hand. This is done in Venice by cottage labour of women and girls. It is not an unusal sight in the Castello section of Venice to see a group of women and girls sitting in the streets, each with a pan of beads in her lap, threading and gossiping at the same time. The needles are about the length of knitting needles, but much smaller in diameter, with an eye for the thread at the lower end like an ordinary hand-sewing needle. The worker takes a number of these needles and spreads them out like a fan or the tail of a peacock, holding them thus grouped in one hand and thrusting the ends into the pan of loose beads until they are covered for almost their full length, when the beads are slipped down on the threads and the needles are again arranged to pick up more beads. A good worker can operate 24 needles at a time, and some of the women boast that they can operate 48 needles at once.

(14) The strands of beads are sometimes bunched by the women who thread them and sometimes by girls at the Murano factory. Some classes of beads are bunched for weight and others for number. Many of the small beads are sold by number. Such beads are sometimes referred to as "count beads," while those sold by weight are known to the English trade as "pound beads." The bunched beads are sorted for size and colour and in some cases according to country of destination and are stacked in shelf bins in the warehouse according to a chromatic scale. To look at the side of the warehouse is like looking at a rainbow where the shades insensibly melt into each other.

(15) The bunches of loosely strung beads are usually packed for shipment in small packages (1 lb. or 1 kilo) wrapped in manila paper. The label shows catalogue or list-card classification of the merchandise, and also bears the name of the purchaser (printed) when the purchaser is a regular client and buys in large quantities.

Even the smallest beads may be made in more than one colour and can, in fact, be made in a great variety of colours and patterns. The process is identically the same as for making one-colour beads except that a distinct fondant must be made for each shade of colour. Out of the base fondant is made the cup as described in (3) above. The fondants of the other colours are superimposed on this to make the pattern, reheating the cup as often as necessary but never allowing it to lose its cup form. When all the colours are superimposed it is reheated almost to the point of liquefaction and then pulled into the tube as already described. The ductility of the medium causes the pattern (as is the case with the orifice) to be preserved, even though the tube be pulled out to the diameter of a needle. The different shades of fondant may be applied in complete coatings, like insulations on a wire, or in stripes applied to the base fondant.

If the fondant is not cupped, but is pulled out in a solid rod instead of into a tube or cane, a cross section of that rod (not its surface) will reproduce any pattern desired. Indeed the pattern may be made with rods of cold glass so staked that their ends form a mosaic. They are then fused to the point of ductility, but not of liquefaction, and even if drawn out to the thickness of a needle a cross section will show the complete pattern. Glass for mosaics (used also for African and mosaic beads), showing patterns of stars, flowers, and geometric designs, is made in that way, and each clipped segment of the rod shows the pattern on its face.

In the first half of the last century Jacopo Franchini, perhaps the most remarkable glass-worker Murano has produced, by binding tiny straws of coloured glass together formed at the end of the rod a miniature portrait or other design. This combination rod was then fused at a blowpipe and drawn out until a rod no longer than a knitting needle might be cut into cross sections, each one of which would show a perfect portrait or perfect design. In the Murano Museum there is a

section of glass rod less than 1 centimetre (centimetre=0·3937 inch) in diameter that shows three perfect portraits side by side, or, rather, in cloverleaf arrangement. Owing to his intense application to so painstaking a work Franchini died in a madhouse, and nobody has since been found who can duplicate his work in glass, although several attempts have been made.

Mosaic beads intended for African and other wild tribes are properly classed with handmade beads, but as a small section of the "canna" is always or nearly always used as the base a description of their manufacture is included here. These beads are not spherical, as pieces from one-half to 2 inches in length are clipped off the canna. These are then fused by blowpipes at Bunsen burners, and mosaic beads are pressed into the surface to give the desired pattern and fused to the point where they coalesce but without losing shape. These long beads with snakelike mottlings and markings are then ground to a smooth surface, strung, bunched, and packed for shipment. Such beads are really individually handmade, although they can be made to set patterns very quickly. Nothing but the canes for these beads are made at Murano; all the other work is done at the Venice plant of the Società. The foregoing covers all the varieties of beads made at Murano. There are certain types of beads, each individually handmade, ornamented, and enamelled at the blowpipe, showing surface patterns of roses and other flowers and designs, that are made exclusively at Venice by expert workmen.

In the making of beads in bulk the fondant is mixed, melted, and moulded by men, and men do all the furnace work and the making of the canes. Men also sharpen the axes of the clipping machines, but the greater part of the detail work of bead-making is done by women. Women operate the clipping machines, sort the beads, sort the canes, operate the machines that string the beads on wires, do the work of stringing on thread and of bunching the beads, do most of the work of preparing the beads for shipment, work at the blowpipe in making and also grind the African beads, and do nearly all the work of manufacture of bead articles. They are paid by the piece and can increase their wages by expertness. At the Murano factory the Società normally employs about 1,000 families on bead-making. A woman's wages vary between 1 and 6 lire per day according to her skill and speed.

IMPREGNATION OF TIMBER.

Large quantities of Norwegian timber were formerly exported for impregnation and re-imported into Norway, but lately a factory has been built in Larvik, where large areas are available for weathering the timber before impregnation. The works are designed to treat 2,300,000 cubic ft. of timber annually, corresponding to about 130,000 telegraph poles. Impregnation takes place in horizontal steel cylinders 6 ft. 6 in. diameter, 85 ft. long, in which trucks fully loaded with timber are placed, the covers firmly screwed down, and the cylinder filled with creosote oil, a pressure of 10 atmospheres being maintained, as it has been found that high pressures are the most effective and produce practically complete saturation. A line of telegraph poles creosoted in this way by the Telegraph Department has kept in good repair during the last twenty-four years, while similar posts of untreated timber rarely have a life of more than eight years.

It is estimated that 1,800,000 cubic ft. of timber may be saved annually in Norway by proper impregnation of all timber used for telegraph-telephone-electric transmission lines and railway sleepers. Thus not only the cost of the timber will be saved, but also the cost of labour for the repairs and the cost of traffic interruption.

Good results have also been obtained with timber structures immersed in sea water. Several instances are given in the *Teknisk Ukeblad* of wooden piers that have been in use for twenty-seven years, while similar piers of untreated timber were destroyed in three to seven years. Impregnated timber is also recommended for paving blocks, fences, and building purposes.

COAL-MINING IN SPITSBERGEN.

Coal was first discovered in Spitsbergen in 1900, when a Norwegian ship exported the first cargo. The Gulf Stream affects the climate on the west coast of the island, where the principal settlements are found, most of the claims being taken up by Norwegian, English, Swedish, and Russian companies.

The Norwegian Spitsbergen Company, which is the principal concern, has acquired one English, one American and one Norwegian company, and in two years exported 85,000 tons of coal. Six other Norwegian companies have started work during the last few years.

The coal, according to the *Teknisk Ukeblad*, is of superior quality, containing very little ash, is comparatively free from sulphur and has a high calorific value, varying from 13,000 to 14,500 B.Th.U. per 1 lb. It is excellent steam coal, but does not contain sufficient volatile matter for a gas coal. It does not clinker.

Mining is easy, as the ground is frozen to a great depth and perfectly dry. There is very little dust and no fire-damp. The temperature of the headings seldom rises above 25° F., but the absence of humidity makes the low temperature quite tolerable. The coal is found below a bed of smooth sandstone, which forms an excellent safe roof.

The upper tertiary beds, which contain the best coal, consist of three seams with a combined thickness of 6 ft. They are separated by beds of shale 1 to 2 ft. thick, and nearly horizontal; the dip being only 2°–3° sporadically, the dip increases to 10°–12°.

The coal in the lowest seam, which is 3 ft. 3 in. thick, is free from shale or other impurities.

The total number of workmen employed is 3,600, and nearly all are from the northern districts of Norway, as the climatic conditions there do not differ greatly from those of Spitsbergen. It is usual to return home during winter. Machinery is utilised for undercutting the coal before explosives are used.

THE USE OF INDIAN OPIUM IN EUROPEAN MEDICINE.

In pre-war times the opium used in this country for medicinal preparations and for the manufacture of morphine was obtained from Turkey and Persia. It was at one time believed that Indian opium was not rich enough in morphine to be employed for these purposes. Although this is true of a large part of the opium prepared in India for export to the East, it is now clearly established that opium suitable in every way for medicinal use in Europe and for the manufacture of morphine can be readily obtained from certain areas in India. So long ago as 1896 the Imperial Institute suggested to the Government of India that the production of medicinal opium for export to Europe should be undertaken. No action was, however, taken in this direction until 1907, when the question was again considered at the suggestion of the Imperial Institute in connection with the restrictions which were then placed on the future export of Indian opium to China. Finally, after the outbreak of war, the Government of India permitted the export of a certain quantity of opium to the United Kingdom for use by manufacturers of morphine, and it is hoped that the trade thus begun will be developed and firmly established.

The proof that Indian opium is of much better quality than was previously supposed is mainly due to investigations carried out at the Imperial Institute. In a detailed report published in the *Bulletin of the Imperial Institute* in 1915 it was shown that of 102 samples of opium from different parts of India about half could be substituted for the best Turkey and Persian opium employed in European medicine, whilst an additional 25 per cent. could be used for special medicinal purposes for which a smaller proportion of morphine in the opium is sufficient. The results of further investigations, which are published in the current number of the *Bulletin*, confirm the earlier opinion as to the high quality of Indian opium. The average amount of morphine in 24 samples from various parts of the United Provinces was found to be above the highest standard demanded by the British Pharmacopœia. In fact 19 of them were so rich in morphine that they would need dilution with lower-grade opium before they could be used for medicinal purposes in the United Kingdom. Similar results were obtained in the case of twelve samples of Benares opium representing the different kinds available for export, all of which were found to be quite suitable for medicinal use or for manufacturing purposes in the United Kingdom.

GENERAL NOTES.

Oxygen in Industry.—Owing to the rapid growth of the nitrate industry based on the fixation of atmospheric nitrogen, the cost of oxygen has fallen enormously since the outbreak of the war. This great achievement in science, whereby oxygen is made a by-product of an important manufacture, is likely to work a revolution in industry. The uses of oxygen, when cheaply produced, are almost endless, says the *Bulletin de la Société de l'Industrie Minérale.* Gas manufacturers will not be slow to utilise it to increase the light of their burners where a strong illumination is required; for that purpose new forms of burners will be called for. In metallurgical operations a small percentage of oxygen blown into the furnaces will raise the temperature considerably. In such cases it will allow inferior and cheaper qualities of coal to be used. Carbide of calcium will be produced in the blast-furnace by a purely thermic method. Alumina will be reduced by carbon. Auriferous quartz will be melted. The glass industry will be revolutionised by the easy fusing of all forms of quartz. A new chemistry, viz., that of the electric furnace, will be created. The manufacture of sulphuric acid will be much accelerated by the powerful oxidation of sulphurous acid. The production of ozone, or electrified oxygen, opens up numerous vistas, notably for the sterilisation of drinking water and the maintenance of a wholesome atmosphere in factories, workshops, schools, theatres, barracks, hospitals, underground railways and mines. For use in mines it may be of inestimable service.

India as a Hardware Market.—The *Board of Trade Journal* points out that in domestic hardware, including enamelled ironware, the position formerly held in the Indian import trade by Germany and Austria has not been completely filled, although Japan has made enormous progress. Greater use has been made of home-manufactured substitutes for the foreign article. Nevertheless, a big business awaits the British manufacturer who can put a cheap article on the market. The position of Great Britain has not been seriously assailed with respect to instruments and tools generally. She should continue to supply her well-known lines, keeping the price as low as possible in view of the competition of Japanese and locally produced substitutes, and of the well-finished American specialities. In cutlery the market is waiting for the full resumption of British supplies. India imports a total value of over a million pounds' worth of heavier hardware, including sugar-mills, oil-presses, water-lifts, and dairy appliances, over three-quarters of this trade belonging to the United Kingdom. Here, again, American and Japanese competition is steadily increasing.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—August 8, 1919.

No. 3482. AUGUST 15, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

// Journal of the Royal Society of Arts.

No. 3,482. VOL. LXVII.

FRIDAY, AUGUST 15, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

H.R.H. THE PRINCE OF WALES, K.G.

A General Meeting of the Fellows was held on Monday, August 11th, for the purpose of electing H.R.H. the Prince of Wales, K.G., a Fellow of the Society. The Chairman of the Council, Sir Henry Trueman Wood, M.A., presided, and proposed the election of His Royal Highness. The motion was seconded by Mr. Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, and unanimously agreed to.

EXAMINATIONS.

In order to encourage the study of Typewriting and Shorthand, and to help to ensure the supply of efficient and educated shorthand-typists, the proprietors of the *Daily Sketch* offer a sum of £1,000 in prizes in connection with the Examinations of the Royal Society of Arts in 1920. The prizes will be as follows:—

Stage III.—Advanced (under age of 31): 1st prize, £250; 2nd, £100; 3rd, £75; 4th, £50; 5th, £40; 6th, £30; 7th, £20; seven prizes of £10 each—£70; eight of £5 each—£40. Total, £675. Stage II.—Intermediate (under age of 26): 1st prize, £60; 2nd, £40; 3rd, £30; 4th, £20; two prizes of £10 each—£20; ten of £5 each —£50; ten of £3 each—£30. Total, £250. Stage I.—Elementary (under age of 19): 1st prize, £10; 2nd, £5; ten prizes of £3 each—£30; ten of £2 each, £20; ten of £1 each, £10. Total, £75.

In addition to the £1,000, the *Daily Sketch* offer a challenge shield to the school or college which trains the winner of the 1st prize of £250.

The *Daily Sketch* will also ask the headmaster and teachers of the same school to accept an honorarium of one hundred guineas, to be divided between them, as they may arrange, in recognition of their work in training the successful candidate.

The headmaster and teachers of the schools where the second and third prize winners of £100 and £75 are trained will be asked by the *Daily Sketch* to accept honoraria of forty and twenty-five guineas respectively.

Candidates for these prizes must pass the Examinations of the Royal Society of Arts in 1920 in Typewriting, Shorthand and English.

The requirements for the different Stages are as follows:—

Advanced Stage.—Advanced Typewriting; Intermediate English (a first-class certificate); Shorthand (120 words per minute).

Intermediate Stage.—Intermediate Typewriting; Intermediate English (a first or second-class certificate; Shorthand (100 words per minute).

Elementary Stage.—Pass in Elementary Typewriting, Elementary English, and Shorthand (50 words per minute).

The above subjects will be taken at the Society's ordinary examinations in March and May, 1920. In the Elementary Stage the prizes will be awarded on the result of these examinations without any further test.

In the Advanced and Intermediate Examinations a number of candidates will be selected by the Royal Society of Arts to compete for the prizes on the result of the above examinations. They will then be required to come to London for a final test for the award of prizes. The expenses of the journey will be borne by the *Daily Sketch*. These tests will consist of:—

Advanced (Stage III.).—1. Typewriting and Shorthand Test: (*a*) Dictation in Shorthand (five minutes at 120 words per minute); (*b*) Typescript of above (twenty minutes). 2. Typescript Time Test (fifteen minutes); technical matter (to test accuracy, speed, and quality of touch, etc.). 3. Preparing a stencil from matter provided and rolling off twenty-five copies (thirty

minutes). 4. Preparing six carbon copies of Tabular Statement (thirty minutes). 5. MS. test. One page of badly-written MS. 6. Paper in English.

INTERMEDIATE (STAGE II.).—1. Typewriting and Shorthand Test: (*a*) Dictation in Shorthand (five minutes at 100 words per minute); (*b*) Typescript of above (twenty minutes). 2. Typescript Time Test (fifteen minutes); ordinary matter (to test accuracy, speed, and quality of touch, etc.). 3. Preparing six carbon copies of Tabular Statement (thirty minutes). 4. MS. Test. One page of badly-written MS. 5. Paper in English.

In addition to the ordinary certificates in each subject the Royal Society of Arts will grant a special Shorthand-Typists' diploma in the Advanced Stage and a special certificate in the Intermediate Stage to all candidates who pass in the three subjects at the examinations in March and May, 1920.

REGULATIONS.—Teachers will not be eligible for prizes, but may sit for the Shorthand-Typists' Diploma.

Age limits will be fixed as follows:—For the Advanced Stage, under 31 years of age; for the Intermediate Stage, under 26 years of age; for the Elementary Stage, under 19 years of age.

Provided the above age limits are not exceeded, any one may sit for the Advanced Stage who is under 31 years of age, for the Intermediate Stage who is under 26 years of age, and for the Elementary Stage who is under 19 years of age.

Students who have already been awarded the Society's Silver or Bronze Medals in Shorthand, Typewriting or English, and who are under 31 years of age, will be eligible to compete for prizes in the Advanced Stage only.

Students who hold or are awarded in 1920 certificates in the Advanced Stage in Typewriting or of 140 or 120 words per minute in Shorthand will be ineligible for prizes in the Intermediate or Elementary Stages.

Holders of Intermediate certificates in Typewriting or of 100 or 80 words per minute in Shorthand will be ineligible for prizes in the Elementary Stage.

Candidates may take the three subjects in March and May, but must take each subject once only. They need not take all three at one examination, *e.g.*, Typewriting may be taken in March, and English and Shorthand in May, etc.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE SCIENTIFIC PROBLEMS OF ELECTRIC WAVE TELEGRAPHY.

By DR. J. A. FLEMING, F.R.S.,
Professor of Electrical Engineering, University College, London.

Lecture II.—Delivered February 17th, 1919.

ELECTRIC WAVE TRANSMISSION.

In the present lecture I propose to consider the problem of the transmission of the long electric waves used in wireless telegraphy over the surface of the earth.

In the early days of radiotelegraphy over short distances the whole effect was regarded as a case of electric wave production in the æther or electro-magnetic medium, and the earth was considered as merely a bounding surface which might be looked upon as a very good conductor, and, therefore, as opaque to these waves.

Such, indeed, is nearly the case when the distance of propagation is only a few miles, although even then the part played by the earth is not merely a negative one; nor can it be considered as if the earth's mass were a good metallic conductor such as copper.

As soon as the range of wireless telegraphy began to be extended beyond very short distances it was at once found that the nature of the surface over which the waves travel exercises a very important action, and, in many cases, seems to rob the waves very quickly of their energy.

It will be necessary to explain that when an electric current is started by an electromotive force acting on a conductor, say, a thick metal bar, the current is not created instantly at all points in the cross section, but begins at the surface and penetrates inwards to the centre gradually. The action is in fact just like putting a poker into the fire to heat it. The surface becomes hot first and the heat penetrates gradually to the interior of the iron bar. We may even go a step further, and say that the law which governs the slow penetration of heat into a conductor exposed to a steady temperature at the outside has exactly the same mathematical form or expression as the law governing the rate of penetration of electric current into a conductor, only the flow of current is vastly more rapid than that of heat.

Suppose that the poker is alternately exposed

to great heat and great cold, as, for instance, by being placed for a few minutes in a fire and then placed for an equal time in ice-cold water. Then it is clear that their changes of temperature will not penetrate into the metal beyond a certain depth, but will be confined to an outer layer of a certain thickness.

This is the case with the earth itself. The diurnal, and also the annual, surface alternations of temperature are not felt below a certain depth on the earth's crust.

In the case of high frequency alternating electric currents this skin or layer of the conductor is very thin if the conductor is an ordinary metal. Thus, for copper, and for a frequency of 100 or so the effective layer may be about three-quarters of an inch, whereas for a frequency of a million the skin would not be more than about one-hundredth of an inch in thickness. If the material of the conductor is magnetic like iron, then this tends to reduce the thickness of the skin, and hence alternating currents penetrate less into iron than they do into copper.

We can easily prove this experimentally as follows: A circuit is constructed consisting of a rectangle of copper wire with three gaps in it on three sides. One gap is filled by a pair of spark balls with an interval of an eighth of an inch or so. A second gap is filled by a Leyden jar having its inside connected to one side of the gap and its outside to the other. The third gap can be bridged by a spiral of copper, iron, or galvanised iron wire, all three spirals being of the same size of wire and number of turns.

Alongside of this rectangle is placed an instrument, called a cymometer, comprising a spiral inductance and condenser of variable capacity. The surfaces of this condenser are connected to a vacuum tube filled with neon gas. Electric oscillations are set up in the first circuit by connecting the spark balls to the secondary circuit of an induction coil, so that the Leyden jar becomes charged, and then discharges across the spark gap with oscillations. The spiral of copper wire is then inserted in the third gap and the cymometer adjusted to be in tune with the primary circuit by varying its inductance and capacity. The neon tube will then glow brightly. If then the iron wire spiral is substituted for the copper, the glow in the neon tube diminishes because the iron damps out the free oscillations more quickly than the copper. If, however, we substitute the galvanised iron spiral, the glow is restored showing that an iron wire covered with a thin coating of zinc or galvanised behaves just as a wire not made of magnetic material. This proves completely that the oscillations are confined to the surface of the wire.

It is not difficult to prove that when using electric oscillations having a frequency n, and a material having resistivity ρ and magnetic permeability m, that the current penetrates into the material to a distance of about

$$0 \cdot 637 \sqrt{\frac{\rho}{m\,n}}$$

Thus if $n = 1{,}000{,}000$, $m = 1$, and $\rho = 1{,}600$, as it is for copper, then the skin thickness is about $\frac{1}{4}$ mm. If, however, we employ iron, for which $\rho = 10{,}000$ and m may be, say, 900, the thickness would be about $\frac{1}{50}$ mm., or, say, only $\frac{1}{12}$ of that in the case of copper. The earth's crust materials may be taken to be practically non-magnetic, but they have much less conductivity than any metal. Thus for sea-water we may take the resistivity to be approximately 25 ohms, or 25×10^9 C.G.S. units per centimetre cube, and hence the penetration into it of a current, of which the frequency is a million, would be approximately 4,000 times greater than if it had the same conductivity as copper. In other words, for sea-water and for an alternating E.M.F., having a frequency of a million, the current is practically confined to a depth or thickness of about one metre. For solid earth crust materials, such as sand, soil, rocks, etc., moist or fairly dry, the penetration will be much greater, because the conductivity is much less or resistivity much greater than for sea-water.

When an electric wave travels over the surface of the earth, we have seen that the electric force is perpendicular, and the magnetic force parallel to, the surface. These effects penetrate into the earth and give rise to electric currents in it, and these currents dissipate energy. If the earth were a perfect conductor, there would be no penetration, and hence no loss of energy from the wave. If the earth were a perfect insulator, the wave would travel freely through it, but there would be no production of conduction currents, and consequently no loss of energy. It is easy, therefore, to see that, for some intermediate dielectric conductivity there will be a maximum value for the energy loss. Mathematical discussion of the problem shows this to be the case, and that for each particular dielectric there is a certain conductivity for which the absorption of energy is a maximum.

This varies with the frequency of the oscillations, or with the wave length. It is convenient to estimate the soil absorption, by

stating the distance a plane electric wave would have to travel over it, in order that the wave amplitude may be reduced to ϵ^{-1}, or to 0·368 of its initial value. Both theory and practice lead to the conclusion that when transmitting over fairly dry and also over moist land, lengthening the wave is of great advantage in reducing the absorption of energy. It seems also to be the case that foliage and forests have a considerable wave energy absorbing power. It is found that in certain districts the soil exercises a peculiarly weakening effect upon waves of a certain wave length. Thus Dr. L. W. Austin has pointed out, as a result of certain careful measurements, that the soil to the north and north-east of Newport, Rhode Island, U.S.A., shows a very large absorptive power. During experiments made in 1910, between the United States Navy radiotelegraphic station at Brant Rock and a United States cruiser, "Birmingham," forty-five miles away, measurements were made of the received currents, when waves of 1,000 and 3,750 metres respectively were sent over, the sending aerial currents being in both cases 27 ampères. The received currents were 1,050 microampères for the short wave and 1,000 for the long wave. Calculating from the well-known inverse distance and inverse wave length law, from measurements made close to the sending station, the received currents should have been 5,400 and 1,550 microampères respectively, thus showing that the amplitude of the short wave was only one-fifth of what it should have been, whilst the long wave was hardly weakened at all except by distance. This shows that 95 per cent. of the energy of the short wave had been absorbed in some manner by the soil.

It is clear, therefore, that in fixing upon sites for radiotelegraphic stations, particular care should be taken to explore the district, first by experimental stations, to avoid these regions of great absorption. Geological examination of these absorptive districts will no doubt in time enable predictions to be made, and this exploration would be assisted if means can be found to determine the dielectric constant and the electric conductivity for high frequency currents of large scale samples of the soil, that is to say, masses of several cubic metres in bulk, and not mere hand samples. This is one of the unsolved problems of radiotelegraphy.

We turn next to the consideration of a most important matter, which has occupied the attention of many eminent mathematicians, viz. the effect of the curvature or sphericity of our earth on electric wave propagation over it. For short distances up to 100 miles or so, the earth may be considered for radiotelegraphic purposes to be a plane surface, but for distances such as 1,000 miles or more we have to consider the effect of sphericity. As is well known, wave motion tends to bend or to be diffracted round obstacles. The explosion of a gun can be heard, although it may be fired on the other side of a hill. The voice of a speaker is heard, even if a house interposes. In the case of the extremely short æther waves which constitute light, there is a small degree of bending or diffraction round an opaque object. But such bending is determined by the ratio of length of wave to size of object. In the early days of the undulating theory, the real difficulty felt was to explain how it happens that small sources of light can cast sharply-defined shadows. The rationale of this is revealed in the Huyghens principle, as developed by Fresnel. This principle states that each point in a spherical wave front acts as a new centre of disturbance and sends out spherical waves. Also, when waves differing in phase by half a wave length arrive at any point simultaneously they extinguish each other. Accordingly, if from any point we draw radii cutting the advancing wave front, so that these radii differ in length by half a wave length, these lines will cut up the spherical advancing wave into sectors of nearly equal length, except at places near the line joining the source of light to the point in question. The light from these sectors, taken pair and pair, will annul itself, and leave only as effective that coming from the central sections. It follows from this that there must be a small extension of lighted area into the region of the geometrical shadow.

This spreading or diffusion of the wave motion into the true shadow area is called diffraction. In the electrical problem presented to us we have to consider the diffraction of electric waves round a sphere. We suppose a Hertzian oscillator small compared with the radius of the sphere placed with its axis along the polar radius and just at the surface of the sphere. The problem then is to calculate the magnetic and electric forces due to this oscillator at any point on the sphere. The problem is one of considerable difficulty and has engaged the attention of several eminent mathematicians. It was first considered by Professor H. M. Macdonald in 1903, but his results were criticised by Lord Rayleigh and by the late Professor H. Poincaré.

In a subsequent paper Macdonald amended his work and gave a table showing the decay in amplitude of electric waves 1,000ft. in wave length at various distances. The problem was subsequently attacked by Professor J. W. Nicholson, and also by two Continental mathematicians, March and Rybczynski. It has also been carefully considered by Professor A. E. H. Love, and more recently still by Dr. G. N. Watson. Owing to the difficulties of the approximations required none of these mathematicians entirely agree in the final expressions they deduce for the magnetic force at various angular distances from the oscillator

Taking the latest results of Macdonald and of Nicholson I have calculated numerically from their respective formulæ the relative amplitude of electric waves of 8 kilometres (five miles) in wave length sent out from a wireless station for various distances from their respective formulæ. The formulæ are not valid close to the oscillator, so I have taken the amplitude or magnetic force in both cases to be represented by 100,000,000 at a distance of 500 miles from the transmitter, and have computed its value at various distances up to 6,000 miles measured along a terrestrial meridian. It will be seen that the force decays much faster according to the formulæ of Macdonald than by the formulæ of Nicholson. Nevertheless we may say that up to 2,000 or 3,000 miles there is very considerable diffraction or bending of the waves round the earth.

In this case the ratio of wave length to diameter of the earth is $5 : 8{,}000 = 1 : 1{,}600$. For still greater distances the amount contributed by pure diffraction is small. Generally speaking, mathematicians have assumed the earth to have perfect conductivity. The results, however, are not very seriously altered if we take the earth to have the conductivity of sea-water.

Much time and thought have also been spent on the work of attacking the problem from its experimental side. The theory of the Hertzian oscillator in free space has been completely treated by Hertz and others, and it shows that for a Hertzian oscillator at distances large compared with the wave length emitted the magnetic and electric forces vary inversely as the distance from the oscillator. It was experimentally proved by Duddell and Taylor to be the case for a wireless antenna emitting electric waves 400 ft. in wave length up to a distance of 6,500 ft. or so.

The first important long-distance experiments were carried out in 1909 and 1910 by the United States Navy Department with the aid of two cruisers, "Birmingham" and "Salem," and the co-operation of the Brant Rock high-power radio-station near Boston, U.S.A. The cruisers were equipped with receiving apparatus, and measurements of signal strength could be approximately obtained by shunting the telephone used to receive signals until these signals could be just not heard. This is at best a somewhat rough method, but it is the only one which seems possible on board ship where the use of galvanometers is out of the question. These experiments were under the care of Dr. L. W. Austin, and the results were described by him in 1911. The wave lengths employed were 1,000 metres and 3,750 metres. Up to 100 miles or so the law of wave amplitude diminution was found to follow approximately the inverse distance law. Also the receiving aerial current, which may be taken as proportional to the amplitude of the incident electric waves, varied inversely as the wave length. These two facts are easily deduced as consequences of the theory of the Hertzian oscillator. As soon as the distance between sending and receiving station was increased to more than 100 miles or so it was found that the received aerial currents fell off much more rapidly than the simple inverse of the distance between the stations. Also it was found that they decreased faster by day than by night, and that the signal strength by night was very irregular.

Senatore Marconi had in 1902 discovered the great difference between the maximum range of signalling by day and by night with given apparatus. In one of his voyages across the Atlantic in the steamship "Philadelphia" he had found that certain signals sent from Poldhu by daytime ceased to be audible by telephone at about 700 miles, but continued to be detectable up to 1,550 miles by night. From and after that discovery this day and night difference became the subject of much investigation.

Taking the daytime observations as most uniform, Austin plotted the results in curves showing the receiving antenna currents in microampères in terms of the distance from the sending station in miles. He assumed that the departure from the inverse distance law was due to an "absorption" of some kind and might mathematically be expressed by an exponential factor. Hence he deduced an empirical formula for the receiving antenna, current (I_R) in terms of the sending antenna current (I_S), the heights of the two aerials

(h_1, h_2), the wave length (λ), and the distance d, as follows—

$$I_R = 4\cdot25 \frac{I_s h_1 h_2}{\lambda d} \epsilon^{-\frac{a d}{\sqrt{\lambda}}}$$

where I_R and I_S are reckoned in ampères and λ, h_1 h_2 and d in kilometres and a is a constant that he called the absorption co-efficient, which was 0·0015.

This formula is, however, purely empirical. It is quite certain that the laws of propagation of electric waves round the earth cannot be represented as if due to propagation by a Hertzian oscillator in free space, combined with an "absorption" of some kind. Nevertheless, Austin maintains that the observed day-time results, up to 1,000 or 2,000 miles, agree with the above formula.

Another valuable set of long distance observations were carried out by J. L. Hogan, jun., in 1912–1913, with the aid of the United States cruiser "Salem," up to 2,500 miles distance (= 4,000 kilometres). The measurements of signal strength were made by the shunted telephone method. The day-time results were found by Hogan to agree with an empirical formula—

$$I_R \text{ (in microampères)} = \frac{395\, I_s h_1 h_2}{d\lambda} \epsilon^{-0\cdot0047 \frac{d}{\sqrt{\lambda}}}$$

where h_1 and h_2 are reckoned in feet, d in kilometres, λ in metres, and I_s in ampères.

It will be seen that even the exponent of the absorption factor does not agree with that deduced by theory, being $\lambda^{-\frac{1}{2}}$ instead of $\lambda^{-\frac{1}{3}}$.

Professor A. E. H. Love has criticised these results, and maintains that the experimental results fit in with and confirm Macdonald's formula.

The latest discussion of this problem of the law of variation of signal strength with distance, over the earth's surface, has been given by Dr. G. N. Watson. He has considered first the problem of the diffraction of the waves round the earth, and has arrived at a formula substantially identical with that of Professor Nicholson. He finds that at the antipodes of the sending antenna there would be no magnetic force due to diffraction. In view of the fact that the Carnarvon radio station of Marconi's Wireless Telegraph Company has transmitted messages without repetition to Australia, this affords strong proof that wave diffraction alone will not account for long distance wireless telegraphy. But Dr. Watson has considered also the problem of transmission by ionic reflection, and finds that from theory it can be predicted that the law of decrease would involve an exponential term which, in the index, includes as a factor the inverse square root of the wave length.

The great difficulty which arises in testing by experiment any formula, whether empirical or theoretical, is the manner in which the maximum signalling distance for given sending and receiving apparatus varies in an arbitrary and irregular manner. Not only is it generally greater, but more irregular by night than by day, but at all times seems to undergo sudden changes, and to vary with direction. Ships equipped with short distance radio-apparatus usual for communications over 300 or 400 miles, occasionally receive or transmit signals 1,000 miles or more, and the signals for long distance stations also vary in a similar manner. These feats and irregularities strongly indicate that, in addition to normal wave propagation, assisted by diffraction, there are causes at work to assist long-distance transmission which are irregular and variable.

The study of these irregularities has brought us to the conclusion that long distance radio-transmission is greatly affected by the earth's atmosphere, and particularly by its state as regards ionisation or the presence in it of electrified particles, corpuscles, or electrons. A few words must then be said by way of explanation on this subject. The atmosphere consists at the earth's surface of a mechanical mixture of oxygen and nitrogen, in the proportion of about 21 to 79 by volume. In addition, there is a small proportion of carbon dioxide, and a variable amount of water vapour, and very small amounts of non-valent gases, viz., argon, helium, neon, krypton, xenon, and also of hydrogen gas. Up to a height of ten or twenty miles or so winds and motions of the gases due to convection keep the constituents well mixed up, although there is a gradual diminution in general density as the height increases, and also a reduction in mean temperature. Above this height we pass into a region where convection and winds cease, and the gases begin to sort themselves out, according to density. Oxygen and nitrogen gradually disappear, and at great heights of sixty miles or so the predominant atmospheric gases are hydrogen and helium, with possibly some of the rarer gases neon and krypton.

The water vapour and clouds are confined to a stratum, extending up to about ten miles or so in height. Above that region there is an undisturbed clear and cloudless atmosphere.

When sunlight passes through this upper atmosphere, the extremely short waves of ultra violet light act upon the molecules and liberate electrons or particles of negative electricity. The residue of the molecule forms what is called a positive ion, and the electrons may attach themselves to other molecules forming negative ions.

This ionisation is only affected by rays of very short wave length, about 1,350 Angstrom units in length (1 A.U. = 10^{-7} mm.) or less. Hence this short wave ultra violet light can ionise the atmospheric gases at high levels by day, but the ionisation to a large extent disappears at night. There, is however, another cause of more permanent ionisation.

The atmosphere of our sun is not only at a very high temperature of about 6,000° C. at the outer layer of the photosphere, but is in a constant state of eruption due to chemical actions, violent convection, and explosive operations. These solar volcanic actions throw up gases and metallic vapours, which latter condense into metallic mist at certain heights.

Maxwell proved that light waves must exert a pressure on objects exposed to them, and this has been experimentally confirmed by Nichols and Hull and by the late Professor Poynting. The pressure due to full sunlight falling on a black object at the earth's surface is very small, amounting only to about 2·8 lb. per square mile. But near the sun's surface his light intensity is 46,000 times greater than at the earth's surface and light pressure there amounts to 58 tons per square mile.

Consider now a small particle of dust near the sun's surface. It is attracted to the sun by gravitation, and this is twenty-seven times greater than the attraction of the earth or an equal particle at the earth's surface. This gravitation attraction varies as the mass or as the cube of the diameter of the particle. The light pressure varies as the surface or as the square of the diameter. Hence, if the particle is continually diminished in size the gravitation attraction will decrease faster than the light pressure and at and below a certain diameter the particle would be repelled from the sun. For a density equal to water the critical size is about 0·00013 cm. in diameter, at which the attraction and repulsion just balance. The light pressure is at a maximum for a wave length equal to the circumference of the particle. Hence, when violent uprushes of solar gases take place resulting in condensation to solid particles of various sizes at certain heights, a sorting action begins due to light pressure. The particles of larger size are drawn back into the sun by gravitation. Those at the critical size may remain suspended at a certain height and those of still smaller size are repelled from the sun by light pressure.* Hence there must be streams of such small particles passing outwards, and some strike the earth moving in its orbit.

I have calculated the time required for particles of certain sizes to make the journey from the sun to the earth under the action of this light pressure, and also the velocity with which they would enter our atmosphere. Taking the particles as spherical and of unit density and diameter, 1,600, 5,000, and 10,000 Angstrom units, I find these times and velocities to be as follows—

Diameter.	Time of transit.	Velocity in kilometres per second.
1,600 A.U.	25 hours 17 min.	1900
5,000 A.U.	55 hours 33 min.	1000
10,000 A.U.	112 hours 17 min.	550

In calculating the velocities I have assumed that the particles are shot out of the sun with a velocity of 200 kilometres per second. From these figures we can calculate the energy in horse-power hours which one kilogramme of dust of particles of these three sizes would convey to the earth, and it is—

For 1,600 A.U. 700,000 horse-power hours
5,000 A.U. 180,000 ,, ,,
10,000 A.U. 55,000 ,, ,,

Hence as much of this finest solar dust as one could carry in one's pocket—viz., 2·2 lb.—would, in virtue of the enormous velocity it acquires under solar light pressure, bring to the earth enough energy to run one of our largest battle-cruisers for twenty-four hours.

This energy must in some way or other be utilised, and it probably expends itself in ionising the gases in the very highest layers of the earth's atmosphere. Each particle of dust is probably condensed round a negative or positive electron, and thus forms an ion, and

* It is possible that the solar corona or luminous envelope seen round the sun when the disk is totally eclipsed by the moon may in part, at least, consist of dust particles thus held in balance or suspension at regions where the light pressure just balances the gravitation attraction. Observations with the polariscope show that the light from the corona is in part due to solar light reflected from small particles. The different outline of the corona at times of maximum and minimum sunspot eras may be due to variations in solar luminosity or to the variation in the direction in which the solar dust is first projected. At minimum sunspot eras the spot zones appear to draw near to the solar equator, and this may perhaps account for the extension of the corona in the equatorial direction, which is a known characteristic of it at minimum sunspot periods.

these break up or ionise the molecules of the atmospheric gases. The highest levels of the atmosphere are, therefore, in a state of permanent ionisation. The ionisation produced by solar light exists more by day than by night. Hence it has been assumed with some degree of justification that there are two layers of strongly ionised gases in the upper atmosphere. First, a permanently ionised layer, and below that a diurnally ionised layer.

It has been shown by Dr. Eccles that electric waves must travel rather faster through a gaseous dielectric in which there are heavy ions, or groups of gas molecules clinging round an electron. The result of this will be to produce a refraction or bending of an electromagnetic ray quite analogous to that produced on light rays by a very much heated layer of air near the ground. This effect creates the phenomenon known as the mirage, and in like manner a rather sharply-defined overhead layer of strongly ionised atmosphere may create an inverted mirage effect, and so bring down again to earth an electromagnetic ray which would otherwise escape into space.

A theory which has gained some support is, therefore, as follows. Long distance wireless telegraphy is to a great extent the result of this overhead refraction or reflection of electromagnetic rays by layers of ionised air. The electromagnetic rays are brought to the distant receiver, not by diffraction but by reflection. Just as in the case of the setting sun we derive light from reflection from overhead clouds, lit up by the sun after it has sunk below our horizon, so a wireless transmitter "lights up" distant receivers by reflection of its rays from overhead masses of ionised gases.

If then during daytime the ionised layer extends lower down, the rays may be bent down more sharply by day than by night, and the range of signalling abbreviated or reduced.

There are also many curious effects which take place just at sunrise and sunset—that is, when the receiving or transmitting stations are near the boundary surface of the earth's shadow. The simplest method of describing these is to refer to the description given in 1911 by Senatore Marconi of the diurnal variation of signal strength between the transatlantic stations at Clifden (Ireland) and Cape Breton (Nova Scotia). He said:—"Waves of 4,000 metres length crossing the Atlantic from west to east, yield strong and steady signals all day at Clifden, which gradually weaken after sunset at Clifden, reaching a minimum about one and a half hours afterwards. The signals at Clifden then gradually increase in intensity till after sunset at Cape Breton, when they attain a maximum which is occasionally very high. During the night they are very variable in strength. Slightly before sunrise at Clifden the signals grow stronger, and sometimes pass quickly to a high maximum. They then dwindle to a marked minimum about two hours after sunrise at Clifden, and then return to normal day strength."

A consideration of this statement will show that the boundary surface between the earth's shadow and the illuminated portion of the atmosphere acts like a partial reflector when it comes up behind the transmitting station. But when this boundary plane interposes between the transmitting and the receiving stations it reduces the signal strength. It seems as if the boundary surface between ionised and non-ionised air acted like a semi-opaque screen to ordinary light as either a partial reflector or partial absorber, according to whether it is placed behind or in front of the source of light.

There are also curious differences in the facilities with which radio signals can be sent in north and south or east and west directions.

Again, in addition to regular diurnal changes in signal strength, there are irregular variations from day to day and hour to hour. The causes of these may perhaps be found in drifting masses of ionised air.

There is one additional cause of curvature in the path of an electric ray, sent out parallel to the earth's surface from a sending aerial, and that is the normal refraction of the atmosphere. Owing to the diminution of air pressure, and, therefore, of dielectric constant as we rise up in the atmosphere, the upper portions of a plane wave, with wave front perpendicular to the earth at the sending station, travel faster than the lower, and hence to a slight extent this tends to make the ray follow round the earth's curvature. I have found by calculation that if the earth were twice its present diameter the horizontally emitted ray would follow exactly the earth curvature. Also if the atmosphere consisted of krypton it would do so with the earth its present size.

LAC CULTIVATION IN INDIA.

The lac industry has for many years formed the means of livelihood of thousands of the poore classes of India, especially those inhabiting the outskirts of the forests and other areas where the lac insect abounds.

Lac is a secretion produced by an insect which sucks the juice of plants and transforms it into resin. This secretion hardens on exposure to the air into a deep-red or orange-coloured substance, semi-transparent, and breaking with a crystalline fracture. The insect belongs to a group commonly known as scale insects.

At the time of emergence the young insect is about $\frac{1}{25}$ of an inch in length and deep-red in colour. After sluggishly wandering about and finding a suitable spot, it fixes itself and then thrusts its beak into the tissues of the stem and begins sucking the juice. The sap thus taken into the body is greatly transformed, and is given out uniformly through pores all over the body in the form of resin, which after a few days encases the insect completely. Female insects remain fixed once for all, but male insects emerge twice a year, sometimes as winged creatures.

The lac-bearing branches are cut off and placed on trees having a sufficient number of succulent branches. When the young insects have swarmed out, the old lac-bearing branches are removed and the resinous incrustation (stick-lac) is scraped off with a knife, ground in a mill, soaked in water, and washed. The pure animal resin (seed-lac) thus obtained is mixed with colophony and orpiment, cooked over a slow fire and drawn out into thin sheets, in which form it is commercially known as shellac.

The United States Vice-Consul in Calcutta calls attention to some interesting details furnished by Mr. C. S. Misra, first assistant to the Imperial Entomologist at the Agricultural Research Institute, Pusa, regarding the present condition of lac cultivation in the plains of India. During the last decade the industry has passed through many vicissitudes. Over-production, no doubt, contributed to a large extent to the lowering of prices of the crude material. Prices reached their lowest point about a year after the outbreak of the Great War—22 rupees per maund (about £2 per cwt.)—at which figure lac cultivation is hardly worth while. New uses were then found for shellac, and its exportation was limited, after which prices rose. With the steadying of prices of shellac the flow of the crude material has again become about normal. One result of the stimulus afforded by present high prices is that many persons have started the cultivation of lac in localities where success is doubtful, because the climatic conditions—an important factor in the development and subsequent acclimatisation of the lac insect—are decidedly unfavourable. On the other hand, few new attempts at lac cultivation have been made in localities which at present meet practically three-fourths of the world demand.

India is the only country in the world, says Mr. Misra, which supplies the market with shellac in its various manufactured forms. The Japanese have been trying to grow lac in Formosa, the Germans experimented with lac in Amani (German East Africa), and the Department of Agriculture in Egypt has also tried to introduce the industry there. The Indian Agricultural Research Institute furnished brood-lac for these three experiments, but definite information regarding their success or failure has not yet been received.

In years when the prices rise, as was the case from 1905 to 1907, and again during 1915 and 1916, attempts are made to oust the natural lac from the market with a synthetic product, but these attempts prove unsuccessful, as the constituents of the synthetic article either cannot be obtained in bulk or the cost of manufacturing it leaves too small a profit. However, it is reasonable to expect that the partiality at present shown by consumers for shellac, which even in its standard form is more or less adulterated with foreign ingredients, such as colophony and orpiment, will at some time give way to a preference for seed-lac, which is a pure animal product, and in which impurities can be easily detected.

The Agricultural Research Institute at Pusa has conducted experiments in the treatment of pure lac by grinding stick-lac to standard size, soaking and washing in water, adding monohydrated sodium carbonate, then aerating, and frequently turning in the shade until thoroughly dehydrated. Samples of the product, which was a beautiful pale brown in colour and considerably superior to the seed-lac obtained without the addition of the alkali, were judged by a London firm to be twice the value of the untreated product.

It is pointed out by Mr. Misra that the supply of stick-lac can be increased by removing all the lac from the trees a fortnight before the swarming of the young insects takes place and putting it on trees already pruned for the purpose, and then not gathering the stick-lac until after the swarming occurs, instead of before, as has often been done. Prior to 1908, when lac dye was a marketable product of considerable importance, it paid to remove the stick-lac before swarming and when rich in colouring matter; but now, with the introduction and extensive use of aniline and other dyes, lac dye has sunk into insignificance. Experience has shown that stick-lac obtained from pruned trees is richer in resinous content than that obtained from unpruned trees, and that the successive broods reared on pruned trees are not so liable to disease. It is also a noteworthy fact that brood-lac should be obtained from a locality having similar climatic conditions to those obtaining in the place to which it is to be transported, and that brood-lac does best when transferred to a tree of the same species as the one from which it was taken.

The heaviest lac production is in the north-eastern section of the Indian Peninsula, in parts of the United Provinces, Central Provinces, and the Province of Bihar and Orissa. There is also an area in Eastern Burma, one in Western Sind, and a section of Central Assam, where quite large quantities of lac are collected, as well as smaller quantities in scattered sections.

The value of the shipments of lac (mostly shellac) from India in 1916-17 was £1,819,000, 78 per cent. going to the United States, which has been the largest buyer of Indian lac for the last twenty years.

The extent to which export values have risen is clearly seen in the 1916-17 trade figures; for, with a total value of £704,000 greater than in 1915-16, the quantity of lac shipped from India was 35,971 cwt. less. Exports to the United Kingdom —India's second best customer—showed a decline of nearly 50 per cent. in quantity in 1916-17. Practically all the lac exported from India now goes out through the ports of Bengal, as the following table shows:—

	1915-16. cwt.	1916-17. cwt.
Exported from Bengal	415,781	380,701
,, ,, Bombay	45	94
,, ,, Sind	678	478
,, ,, Madras	723	2
,, ,, Burma	93	74
Total	417,320	381,349

In 1917-18, India's shipments of lac of all kinds (excluding lac dye) reached the record value of £2,451,000, accompanied by a drop in quantity exported to 322,420 cwt.

SCIENCE EDUCATION IN GREAT BRITAIN.*

Not for the first time our educational conscience has been stung by the thought that we are as a nation neglecting science. Attention was called to this neglect by the Report of the Royal Commission on the nine public schools in 1864, when it was recommended that all boys should receive instruction in some branch of natural science during part at least of their school career. A Committee of the British Association dealt with the subject again in 1866, drawing the valuable distinction between scientific information and scientific training, and making recommendations which influenced the course of science teaching in schools. That there was need for these exhortations can be proved without any elaborate survey of the history of science teaching in England. In 1863, at the very time the Public Schools Commission was holding its inquiry, the only instruction in science at one of the greatest schools in England was given on Saturday afternoon by a visiting teacher, and his meagre apparatus was stored in so damp a cupboard that his experiments usually broke down. It is not surprising that the headmaster of this school told the Commissioners that "instruction in physical sciences was, except for those who have a taste, and intended to pursue them as amateurs or professionally, practically worthless." Steps had been taken before these dates at certain schools to introduce the teaching of science, but this work was done under great difficulties and was regarded with jealousy by the staffs, with contempt by the boys and with indifference by the parents.

Gradually, thanks to these reports and to the efforts of gifted teachers within the schools, this Benjamin of subjects won toleration if not affection in the family circle. Meantime public interest in science was being aroused by the achievements of scientific workers like Darwin and Kelvin and by the writings of Spencer, Kingsley, Tyndall and Huxley, and this interest was reflected in the schools.

During these years, however, secondary education was within the reach of but few. The big public boarding schools—then to be numbered on the fingers of two hands—educated a limited number for whom a road had been made by family traditions or increasing wealth; the old-established grammar schools scattered sparsely over the country offered to others in their immediate neighbourhood opportunities of education often most eagerly seized and fruitfully used; but boys, even though they found in most schools science teaching available if they sought it out, were sometimes denied it altogether, and they were certainly discouraged from pursuing it unless they had shown incapacity for classics or mathematics. For girls even these limited opportunities did not exist. Information about their education at this period is scanty, but it may safely be said that no organised instruction in science was available for them. These weaknesses, which persisted long after the battle of science was half won, have never been entirely removed by a great stirring of public opinion, even though our defects in scientific education have been fitfully pointed out and to some extent corrected.

Further, while the secondary school, so far as it existed, remained under the classical tradition, the schools which grew up under the Science and Art Department tended to be one-sided in the opposite direction, fostering science to the exclusion of literature. The river of educational enthusiasm, never too strong, was consequently split into two weak streams.

The problem has, of course, been affected by the wide extension of secondary education that has marked the last fifteen years, but the older schools have not yet been entirely freed from all their prejudices, and the newer schools, in spite of their better balance of subjects, may perhaps have missed some of their opportunities.

From schools so few in number and so limited in aim recruits for the Universities could not be obtained in abundance. There were professors of scientific subjects at both Oxford and Cambridge

* Extract from "Report of the Committee appointed by the Prime Minister to inquire into the Position of Natural Science in the Educational System of Great Britain." 1918. [Cd. 9011.] The Committee consisted of seventeen members, and was presided over by Sir J. J. Thomson, O.M., P.R.S., D.Sc. It was asked "to enquire into the position occupied by Natural Science in the Educational System of Great Britain, especially in Secondary Schools and Universities, and to advise what measures are needed to promote its study, regard being had to the requirements of a liberal education, to the advancement of Pure Science, and to the interests of the trades, industries and professions which particularly depend upon Applied Science."

all through the eighteenth and nineteenth centuries, and no doubt they attracted to their lecture rooms individual students, but it was not until half-way through the latter century that the establishment of honour schools in natural science gave formal recognition to the position of science. For some years the scanty class lists bear eloquent witness to the dearth of students. The reports of the University Commissions show how this dearth was not the only difficulty with which the new subject had to cope. Classics and mathematics certainly held a privileged position, and it required the steady efforts of men who were looked upon as dangerous reformers to win the firm ground which science now holds. For instance, at Cambridge H.R.H. Prince Albert, though equipped with the prestige of a Prince Consort and a Chancellor of the University, had to exercise all his tact and influence before the possessors of power there could be convinced that reform was needed.

But Oxford and Cambridge were not to be left in sole possession of the university territory in England and Wales. Durham had been founded in 1832, London University in 1836. Between that date and the end of the century the Royal College of Science was founded in London, and fourteen university colleges were established in the more important towns. Many of these subsequently developed into universities. At both stages of their career they did incalculable service to the cause of science in offering stimulating teaching and opportunities of research to many—men and women—who were pressing to enter the realms of new knowledge. But even though there was a bias in favour of science they were handicapped, as the elder universities were, by a lack of students. Even those with the enterprise to force their way through the obstacles of their circumstances came often ill-prepared by previous education, and much ability was left untapped. That so much was done under such conditions only intensifies our regret that so much was lost. Genius has a way of saving itself, but it cannot be doubted that a sad amount of the general ability on which educational tone and steady scientific progress depend ran to waste for want of opportunity or on account of misdirection.

And now it is the war and its needs that have made us once again conscious of the nation's weakness in science. But it is for the sake of the long years of peace quite as much as for the days of war that some improvement in the scientific education of the country is required. Just now everyone is prepared to receive science with open arms, to treat it as an honoured guest in our educational system, and to give it of our best. Just now it seems almost unnecessary to take action to ensure against any relapse into the old conditions, but experience of the past shows us that temporary enthusiasm needs to be fortified by some more binding material. Goodwill is much, but goodwill weakens, and we must not sacrifice the future to our fears or even to our love of liberty in educational matters. It ought not to be beyond the wit of man to devise a scheme of education that will be durable, yet elastic; a scheme that, while securing that every child should be equipped with a knowledge of science, will not cramp the teacher by a syllabus or even by a rigid tradition.

Some of the advocates of scientific training have damaged their cause by claiming too much for their subject and by seeming to depreciate the value of the literary studies which had tended to monopolise the attention of the ablest boys who enjoyed secondary education. To many Greek and Latin have seemed enemies who, from having occupied the educational ground betimes, have been able to dig themselves in and to hold an almost impregnable position, due not to their merit as educational instruments but to the accident of priority. There is truth in this, but we do not think that the surest method of victory is to be found in the over-statement of the merits of science or the depreciation of the value of classics. Some of the ablest minds have received from their classical instruction enduring gifts that have been of great service to the State and of great refreshment to their possessors. It is our belief that a better service can be done and a like refreshment gained by those whom we hope to see educated on the wider lines laid down in our Report. The humanising influence of the subject has too often been obscured. We are, however, confident that the teaching of science must be vivified by a development of its human interest side by side with its material and mechanical aspects, and that while it should be valued as the bringer of prosperity and power to the individual or the nation, it must never be divorced from those literary and historical studies which touch most naturally the heart and the hopes of mankind.

There can be no need now to labour the important part that science should play in our education, but memories are short and it may be well to register in formal words for future comfort if not reproach, what all would readily grant at this moment. It is not possible to give an exhaustive account of the scope of science, but it is not superfluous to point out that it has several distinct kinds of educational value. It can arouse and satisfy the element of wonder in our natures. As an intellectual exercise it disciplines our powers of mind. Its utility and applicability are obvious. It quickens and cultivates directly the faculty of observation. It teaches the learner to reason from facts which come under his own notice. By it the power of rapid and accurate generalisation is strengthened. Without it there is a real danger of the mental habit of method and arrangement never being acquired. Those who have had much to do with the teaching of the young know that their worst foe is indolence, often not wilful, but due to the fact that curiosity has never been stimulated and the thinking powers never awakened. Memory has generally been cultivated, sometimes imagination, but those whose faculties can best be reached

through external and sensible objects have been left dull or made dull by being expected to remember and appreciate without being allowed to see and criticise. In the science lesson, the eye and the judgment are always being called upon for an effort, and because the result is within the vision and appreciation of the learner he is encouraged as he seldom can be when he is dealing with literature. It has often been noticed that boys when they begin to learn science receive an intellectual refreshment which makes a difference even to their literary work. It is possible to imagine a time when the obstacle to progress in scientific education might be the attitude of scientific teachers, but that time is far distant and it is hard to believe that the teaching of a subject whose life depends on discovery can for long be sterilised, as has been at one time or another instruction in almost all the other branches of human knowledge.

Too few parents of this generation can satisfy their children's curiosity about the wonders of the heavens, the movement of the planets, the growth of plants, the history of the rocks, the dawn of animal life, the causes of tide and tempest.

How necessary science is in war, in defence and offence, we have learnt at a great price. How it contributes to the prosperity of industries and trade all are ready to admit. How valuable it may be in opening the mind, in training the judgment, in stirring the imagination and in cultivating a spirit of reverence, few have yet accepted in full faith.

A nation thoroughly trained in scientific method and stirred with an enthusiasm for penetrating and understanding the secrets of nature, would no doubt reap a rich material harvest of comfort and prosperity, but its truest reward would be that it would be fitted by "an ample and generous education to perform justly, skilfully and magnanimously the offices both private and public of peace and war."

* * * * *

The war, as we have said, has continually hampered us in our inquiry, and it must sadly retard the realisation of our hopes; on the other hand, it has increased the urgent need of action and maybe it has silenced some opposition. It certainly gives no excuse for the postponement of a start to recover lost, and to win new, ground. Such ground, it is true, will never be surely held unless it is slowly won. But it will never be won at all unless the present opportunity is seized. To postpone action until equipment and buildings are perfect, or the supply of wise teachers abundant, until the enthusiasm of the parent is roused or the patronage of the employer is secured, until all fear of officials has vanished and complete confidence exists between the literary lion and the scientific lamb, is to place an obstacle in the way of progress, an obstacle greater even than the war.

Scattered throughout our Report will be found many recommendations and suggestions—the most important and the most urgent of these are summarised at the end. Even whilst we have been sitting measures we have advocated have been taken by more than one of the institutions we have criticised and some of our statements have happily become out of date. But unless the national character suddenly changes there is little danger of chaos being created by a hurried adoption of too many reforms at the same time; so many difficulties clog the feet of advance in all its stages that the competitors are hardly likely to be crowded. What is important is that the course should be cleared and the starting signal given.

MANUFACTURE OF TIN FOIL, JOSS PAPER, AND PEWTER WARE IN SWATOW.

Tin Foil.—The importation of tin in slabs into Swatow amounted to 1,550,800 lb., valued at £108,000, in 1916; and to 1,741,068 lb., valued at £160,000, in 1917. With the exception of Ningpo, Swatow is the largest importer of this metal, which comes chiefly from Yunnan, *viâ* Hong Kong. Practically the whole import is used in the manufacture of tin foil, of which product the Swatow district is the largest exporter, and probably the largest producer in China. In addition to its export as tin foil a large portion is sent out in the form of joss paper.

A small quantity of local tin, said to be 5 piculs (667 lb.) monthly, obtained from the beds of streams in Kityang district, reaches Chaochowfu. Makers of tin foil say that it is 99 per cent. pure.

The chief centres for the manufacture of tin foil, writes the United States Consul at Swatow, are Lienyang in the Chenghai district, Chaochowfu, Saikang in Choyang district, Jaop'ing, and Ungkung; but there are many other places also engaged in its production. For example, in Lienyang, a village of over 10,000 inhabitants, it is the chief industry.

The process of manufacturing tin foil may be conveniently divided into two stages. First, the tin is melted, and its impurities in the shape of scum are removed, for only tin 100 per cent. pure can be used. While in the molten state it is poured into stone trays, forming a thin sheet. When cooled the sheet is cut into small rectangular pieces, 2 by 1¼ in. These pieces, approximately 210 in number, are placed on top of each other on the smooth surface of a piece of granite and beaten with a hammer. When the sheets have attained the desired thinness, another stack of 210 sheets similarly treated is added, and the 420 sheets are hammered as are the original piles. This operation is continued until the pile contains 3,360 sheets or thereabouts, the pounding of which concludes the first stage of the process of manufacture. During the last two beating processes, leather of two thicknesses is placed between the granite slab and the foils, and "waste foil" is used as a covering to reduce tearing from the impact of the hammer.

In the second stage this stack of sheets is first cut into three sections. These are placed on top

of each other and again pounded, this time three thicknesses of leather and more "waste foil" being used to reduce the danger of tearing. This operation is continued until the sheets are about 13 by 18 in., when the process of manufacture is complete. They are then cut into the required size, usually 12 by 9 in., and packed in thin cardboard boxes, the weight of each of which is 1 catty ($1\frac{1}{3}$ lb.), and the contents of which are approximately 600 sheets. It is claimed that out of 100 lb. of tin between 60 and 70 lb. of good foil are obtained.

During the first stage the foil is steamed each night, and during the second stage it is heated in a special oven over a charcoal fire at frequent intervals to prevent the foils sticking together and to secure a smooth surface. This is the new method, and supersedes the use of powder as practised in Chaoyang.

Very few utensils are used in the manufacture. A granite block with a smooth surface is used as the anvil. It rests on the ground, and the workers sit near it on low stools. Two hammers are used; the lighter one, weighing $4\frac{1}{2}$ lb., with a contact surface of about $1\frac{1}{2}$ sq. in.; and the heavier one, $6\frac{3}{4}$ lb., with a contact surface of about $2\frac{1}{4}$ sq. in. The lighter hammer is used during the first three operations of the first stage and the heavier one for the rest of the work. From 10 to 20 workmen are found at each establishment. A good skilled workman, with the assistance of several boys who perform the first stage operations, can produce three boxes (of 600 sheets) per day. The annual output at Chaochowfu is said to be about £160,000 worth, and that of Lienyang between two and three million local dollars' worth.

The export of tin foil in 1916 amounted to 305,733 lb., valued at £46,000; and in 1917 to 346,667 lb., valued at £59,000. About 75 per cent. of this was exported to Hong Kong and the South Sea countries, where there are large Chinese communities. In addition to this export, large quantities were used in the local joss-paper industry, in the manufacture of which it finds its sole use in China.

A possible improvement in the future will be the use of machines in the making of tin foil instead of the wasteful hand methods now employed.

Joss Paper.—The Swatow district is probably the largest producing centre of joss paper in China. Its average annual export amounts to half the total export from all China. In addition to supplying the local demand the following amounts were exported: 7,111,333 lb., valued at £250,000, in 1916; and 7,023,200 lb., valued at £214,000, in 1917. About one-half of the export was sent to Hong Kong, Siam, the Straits Settlements, and the Dutch Indies.

South-western Fukien supplies Swatow with the paper for joss-paper making. Only the lowest grade, third quality, paper is used. Chao-an district is the chief centre of the industry.

The manufacture of joss paper is a simple process. Tin foil and the paper are cut in the desired sizes and shapes—usually square—and a sheet of tin foil is pasted on one side of the paper. In this sheet it is sold to the retailer, and it is he who makes it into the common form of "shoes of sycee" or other forms, the yellow representing gold and the grey silver. It is burned by the Chinese at funerals, at masses for the dead, etc.

Pewter Ware.—Swatow, Chaoyang, and Kaying are the chief centres of production of pewter ware, but to a greater or less extent almost every city supplies its own wants in this line. In the three cities mentioned above the number of workmen is estimated at about 300. Formerly about 500 were employed, the decrease being due to the lessened demand for such ware. The average annual production at Swatow is estimated at £16,000, and at Chaoyang and Kaying between £4,800 and £6,400. Only Swatow produces for export.

The methods of manufacture of pewter ware, as in the case of tin foil, are primitive; few tools are used. By means of a charcoal brazier and a brass or iron pan, the pewter—a mixture of tin and lead—is reduced to a molten state. This molten metal is poured into a mould, frequently composed of bricks, which makes a rough cast of the desired article. It is then shaped by means of a crude lathe, soldered where necessary, engraved or left plain, as desired, and polished. The shaping is done by an iron instrument held in the hands against the article, which is rotated on a foot-tread lathe. Skilled craftsmen at Swatow receive as much as 3*s.* 4*d.* a day, but ordinary workmen only half that amount.

Among the pewter articles of Chinese use are the following: tea-urns, tea-canisters, candlesticks, wine-pots, tableware, joss vases, native oil-lamps, etc. Every well-to-do Chinese family gives, as part of a daughter's dowry, a full set of pewter ware. For foreign use there are mugs, tea-sets, cigar-boxes, cigarette-boxes, match-cases and holders, napkin-rings, cocktail-shakers, liqueur-winecups, tea-canisters, etc. For the natives in the South Seas, betel-nut sets are made.

MANUFACTURE OF LACQUER WARE IN BURMA.

The manufacture of lacquer ware is quite an important industry in Burma, and affords a living for a great many people, particularly at Pagan and neighbouring villages along the Irrawaddy River, about a hundred miles below Mandalay. Pagan, which was the capital of the Burmese kingdom from the second to the fourteenth centuries, when Burmese architecture was at its zenith, is now a little village of a few hundred inhabitants, visited only by tourists attracted there by its ancient architectural ruins. Prome and other cities used to be centres of lacquer-ware manufacture, and a crude class of ware is made in the Shan States, but the most artistic product comes from Pagan.

The lacquer used in Pagan and neighbouring places comes from the Shan States. It is obtained from the thitsi tree (*Melanorrhœa usitata*) in somewhat the same manner as rubber is obtained from the *Hevea brasiliensis*. The thitsi sap is at first a greyish fluid, but it thickens and turns black on exposure. It is lustrous, and takes a fine polish.

It appears from a report by the United States Consul at Rangoon that the articles manufactured at Pagan consist of simple domestic utensils for native use and ornamental work for natives and Europeans, such as bowls of all kinds, cylindrical betel boxes, rectangular cigar boxes, cigarette cases, collar boxes, tables, walking-sticks, and tubular roll-cases; in fact, almost any article may be made to order.

The framework of the article is generally made of closely woven bamboo. It is painted with lacquer, dried, scraped with a knife, caulked with mud, then repeatedly dried; it is then scoured with a powder made of silicified wood and painted until a smooth surface is obtained, after which it receives three coats of lacquer and a finishing coat of "shansi" (a vegetable oil obtained from Moulmein or the Southern Shan States), and is finally smoothed again and polished. The framework of some articles is made of horsehair mixed with bamboo or entirely of horsehair, and these articles are much more flexible and elastic than those made entirely of bamboo.

Articles made of Burmese lacquer are normally black, but the last coats of lacquer are usually coloured with vermilion, which gives a dark red colour. In the ornamental work, the designer scratches the design into the surface with a pointed knife before the article is painted. This is the most skilful part of the work, for the patterns are often of extreme delicacy and perfection. In Pagan and surrounding villages there are only ten or twelve skilful designers. They receive fifteen rupees per month, which is twice the wages of the other artisans engaged in the manufacture of lacquer ware. The designs represent scenes from real life or from Burmese history or legend, and inscriptions make it easy to read the story represented. After the design is made, the article is painted with one of the colours, and before it is thoroughly dry the paint is scoured off with water and paddy-husks, leaving the scratches full of the colour applied. If more than one colour is desired, the article is scratched with another design, painted with another colour, and scoured; and so on, until the desired design is completed, when the article receives a final coat of polish.

Lacquered articles are substantial and durable, and make up a fair proportion of the household utensils used by the natives of Burma. Some of the articles made in Pagan are sold locally, others being sent to Rangoon, Mandalay, and other towns. Few articles are exported, except by tourists.

GENERAL NOTES.

Manchester and Industrial Art.—In their report for the year 1918, the Committee of the City of Manchester Art Gallery say: "At the present moment a movement is on foot, supported by the Minister of Education and the Board of Trade, for enabling an Industrial Art Committee of the Royal Society of Arts to co-operate with the Arts and Crafts Society, the Design and Industries Association, and Consultative Committees of the London County Council, with the object of raising and maintaining the standard of design and workmanship in industrial art produced by British craftsmen and manufacturers, and of stimulating the demand for works of real excellence. Manchester, being as it is the centre of a large group of manufacturing towns, should see that it takes a leading part in this movement, for there can be no doubt that for the healthy development of industry few things are more necessary than that it should draw constant inspiration from the best designers and artists. Successful industry is, in fact, and always must be, intimately bound up with art, and the provision of an art gallery in which examples of the best obtainable work in the main branches of the industry can be seen and studied by the people is, in the opinion of the Art Gallery Committee, a practical movement for stimulating trade and for giving art its rightful place in the life of the community."

Institute of Metals.—The autumn meeting of the Institute of Metals will be held in Sheffield on September 24th and 25th, and it is expected that some hundreds of engineers and metallurgists from all parts of the world will take part in the proceedings, which will include visits to several famous works. This will be the first time since 1913 that the Institute has held such a gathering out of London. The following is a list of the communications that are expected to be submitted:—Professor P. G. H. Boswell, O.B.E. (Liverpool), on "Moulding Sands for Non-Ferrous Foundry Work"; Professor C. H. Desch, D.Sc., Ph.D. (Glasgow), Second Beilby Report on "The Solidification of Metals from the Liquid State"; Miss H. E. Fry (Teddington) and Dr. W. Rosenhain, F.R.S., Vice-President (Teddington), on "Observations on a Typical Bearing Metal"; Dr. W. H. Hatfield and Captain G. L. Thirkell, B.Sc. (Sheffield), on "Season Cracking of Brass"; R. E. Leader, B.A. (Sheffield) on "The Early History of Electro-Silver Plating"; E. A. Smith and H. Turner (Sheffield) on "The Properties of Standard or Sterling Silver, with Notes on its Manufacture"; Dr. J. E. Stead, F.R.S. (Middlesbrough), on "The Ternary Alloys of Tin—Antimony—Arsenic"; Dr. F. C. Thompson, B.Sc. (Sheffield), Note on "Graphite and Oxide Inclusions in Nickel Silver"; Dr. F. C. Thompson, B.Sc., and F. Orme, M.Met. (Sheffield), on "Some Notes on the Constitution and Metallurgy of Britannia Metal."

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—August 15, 1919.

No. 3483. AUGUST 22, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

All communications respecting Advertisements should be addressed to the ADVERTISEMENT MANAGER, 97, GRESHAM STREET, E.C. 2.

Journal of the Royal Society of Arts.

No. 3,483. VOL. LXVII.

FRIDAY, AUGUST 22, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE SCIENTIFIC PROBLEMS OF ELECTRIC WAVE TELEGRAPHY.

By Dr. J. A. Fleming, F.R.S.,

Professor of Electrical Engineering, University College, London.

Lecture III.—Delivered February 24th, 1919.

In this last lecture we shall consider some of the problems connected with the detection of the electric waves sent out from radio-transmitter stations and the manner in which these are controlled to create intelligible signals.

The radiated waves are in the first place picked up and absorbed by a receiving antenna wire similar in construction to the radiating antenna.

It is a fundamental law of radiation that good radiators are good absorbers and *vice versa.* Hence an ærial absorbs best in that plane or direction in which it radiates best. Moreover, an antenna absorbs best radiation of that wave which it would itself emit. Hence the receiving aerial must be tuned to the same wave length as the corresponding transmitting aerial. On the other hand, it is generally not necessary to have such a high or large capacity aerial for reception. A transmitting aerial with its supports is necessarily an expensive structure, but a receiving aerial can be much smaller and cheaper. In long distance stations it is now the custom to have a separate aerial for reception. In Senatore Marconi's system the receiving aerial is generally placed several miles away from the transmitting aerial belonging to the same station.

In order to be able to receive and transmit at the same time the receiving station is provided with two aerials. One which is adapted for picking up the waves from the distant transmitting station, and there is also a second aerial, both being of the bent or directive kind, which is so placed that it can be affected by the waves from the near-by transmitter, but not easily or so much by the waves from the distant transmitter. These two receiving aerials are so connected to the detecting apparatus, to be described presently, that the effects from the near-by transmitter are neutralised on the detector, but the waves from the distant transmitter affect mostly the larger receiving aerial and so make a signal. In this manner the receiving station can receive messages at the same time that the near-by transmitter is sending messages without being "jammed" as it is called.

In smaller stations it is the custom to insert in the base of the aerial near the earth a spark gap or two plates separated by a very small air space. The terminals of the receiving apparatus are connected to either side of this air gap so that arriving waves which impinge on the aerial create currents which pass through the receiving apparatus to get to earth. The transmitter is connected inductively by a transformer with the aerial directly above this gap, so that when the transmitter is in operation it creates a spark which bridges this gap and short circuits the receiving circuit. The whole plant is then always in a condition to receive messages. Nevertheless the operator in this case has to make sure that he has finished taking up all the message to be received before he puts his own transmitter into operation.

When the electric waves impinge on the receiving aerial the magnetic lines of force of the wave cut across the receiving aerial and create an alternating current in it; this current is generally a small one, at best about 5 to 50 microampères, whereas the antenna current in the transmitter is from 5 to 500 ampères. The receiving antenna current passes through one coil of a transformer on its way to earth, and the other coil of this transformer, which is

called the receiving jigger, has a condenser called the tuning condenser across its terminals. There is also a variable inductance coil and a condenser of variable capacity in series with the aerial to tune it. The current set up in the closed receiving circuit is usually made to create by induction currents in one or more associated tuned circuits comprising inductance and capacity.

All the necessary variable inductances and condensers are generally included in one box, called a tuner. The result of this is that we have in a certain final circuit, composed of an inductance coil and condenser in series, a high frequency alternating current of the same frequency as the transmitter aerial current, but not greater than about 40-50 microampères in magnitude. This current in its mode of variation is a copy on a very reduced scale of the sending antenna current. The signals are sent on the Morse International Code by emitting the waves from the sending antenna in short or long groups of trains corresponding to the dot and dash of the Morse code. To do this a key or switch is inserted in the circuit of the oscillation generator, and this key in large stations is operated by an electro-magnet, which in turn is actuated by a feeble direct current controlled by a hand key or else worked by perforated tape on the Wheatstone automatic system.

The result is to produce, in the receiving ærial, groups of decadent or damped electric oscillations, of short or long duration, identical with those set up in the sending antenna. We have next to see how these are detected. These oscillatory currents are far too feeble, and of too high a frequency to affect any ordinary alternating current ammeter or voltmeter. We require a certain special appliance called a detector to make them evident. This detector, so to speak, is sensitive to these groups of feeble oscillations, and in turn actuates some instrument such as a telephone, Einthoven galvanometer, or syphon recorder, which makes the signals evident to the ear or to the eye as dot and dash signals.

Broadly speaking, we may say that five classes of detectors have been used in practical radiotelegraphy: (1) Coherer or contact detectors, (2) magnetic detectors, (3) electrolytic detectors, (4) thermionic detectors, (5) crystal or rectifying detectors. As the first class have now almost entirely gone out of use we need not refer to them. The electrolytic detectors have never been very much used in Great Britain. The magnetic detector, in the form given to it by Senatore Marconi, is a very practical and much used detector, but its use is almost confined to the Marconi and associated companies. The two most extensively used and interesting classes of detectors, which have been the subject of much investigation, are the rectifying crystal and the thermionic detectors.

We shall consider chiefly the thermionic detectors because they came first in point of time, and possess many points of great novelty, interest, and importance. As already explained, the electric oscillations set up in the receiving circuits are of high frequency, and hence cannot directly affect even a telephone. If, however, these oscillations are rectified—that is, if all movements of electricity in one direction are suppressed, these trains of damped oscillations are converted into what is practically a gush or flow of electricity in one direction.

The idea occurred to me in 1904 of seeking for some method of so rectifying high frequency oscillations. It was at that time known that low frequency currents, of frequency 50–200 or so, could be rectified by electrolytic cells of various kinds, and if of sufficiently high voltage by mercury vapour lamps; but experiment showed that these electrolytic rectifiers, like the carbon-aluminium cell, involved a time element in the production of the unilateral conductivity, and could not be used for high frequency rectification. Professor Pupin is stated to have had some success with an electrolytic cell in rectifying Hertzian oscillations, but it may have involved oscillations of rather high voltage, and, at any rate, it never became in use for radiotelegraphic work.

I started on a different line of research in 1904. It has been known for the last half century or more that there were very curious effects connected with the leakage of electricity from very hot substances. Thus Professor F. Guthrie, in 1873, showed that a red-hot iron ball could retain a charge of negative electricity, but not a positive charge, and that at a bright white heat it could not retain either positive or negative. This effect was found to be quite independent of the mode of insulation of the ball. He also showed that a spiral of platinum wire rendered brightly incandescent by an electric current, and held near to the disk of a gold leaf electroscope charged with negative electricity, discharged it, but not if the electroscope was charged positively. These facts, and many others, showed that positive and negative

electricity differ in their relation to heat in a very marked manner.

Passing over an interval of time, we come to the year 1883, by which date the electric incandescent carbon filament lamp had been given to us by Edison and by Swan. In 1883 Edison drew attention to a very interesting effect. He had fixed in the exhausted bulb of a carbon filament lamp, a metal plate carried on a wire sealed through the glass, the plate being held between, but not touching the two legs of the horseshoe-shaped carbon filament.

When the filament was rendered incandescent by a direct current, and when one terminal of a galvanometer was connected to the wire holding the metal plate, Edison found that a current of electricity passed through this galvanometer, if its other terminal was connected to the positive terminal of the filament, but not when connected to the negative. Edison prepared a number of such lamps with metal plates in the bulb, and he showed the effect to the late Sir William Preece in 1884, and it was after that generally called the "Edison effect" in glow lamps. Preece examined the phenomena, and made a number of measurements, and came to the conclusion that the "Edison effect" was in some way connected with the volatilisation of carbon from the filament, but neither he nor Edison gave any explanation of the effect, nor made any technical application of it.

In the year 1882 the writer was appointed Scientific Adviser of the Edison Electric Light Company of London, formed to develop and put in practice Edison's system of incandescent electric lighting. One of the scientific curiosities to which his attention was drawn was that when a carbon filament lamp was overrun at too high a voltage the filament generally burnt out at some point of the filament, and the interior of the bulb was blackened with a deposit of carbon. It was, however, noticed in many cases when the burn-out occurred about half-way down one leg of the hairpin-shaped filament that a white line of no deposit was found on the bulb adjacent to the undamaged leg of the carbon loop. This proved that the carbon particles projected from the overheated point on the filament had been sent off in straight lines and had formed what the writer called, a "molecular shadow." In 1889, 1890, and 1896 the writer examined this matter more carefully and also the "Edison effect," and soon discovered that negative electricity was being given off at the same time from all parts of the incandescent filament. One of his experiments was as follows: A carbon filament lamp was prepared having a metal plate in the bulb between the legs of the carbon loop, and this plate was carried on a platinum wire sealed through the glass. If the plate was connected to a charged Leyden jar or even a very large condenser with the filament cold, and if this condenser was charged with positive electricity, then when the filament was rendered incandescent the condenser or Leyden jar at once lost its positive charge. But if the condenser was charged negatively it did not lose its charge. This fact proved unquestionably that the incandescent filament was emitting in some way negative electricity. At that date Sir Joseph Thomson had not published the remarkable researches which showed that negative electricity is always associated with corpuscles two thousand less in mass than an atom of hydrogen. The writer, therefore, assumed that the carriers of this negative charge were the carbon atoms shot off from the point at which the carbon filament was overheated. This view was subsequently corrected a few years later, when it was proved that the real carriers were the electrons or atoms of negative electricity.

Nevertheless the writer proved by two experiments that the Edison effect was dependent upon the emission of something from the negative leg of the carbon loop which was in a sense material because he found that by surrounding one leg with a glass or metal tube the Edison effect was almost entirely annulled when this leg was the negative leg, understanding by that the side of the loop connected to the negative terminal of the battery used to make the filament incandescent. Again, the effect was greatly reduced by interposing a mica shield between the negative leg and the metal collecting plate. A large number of such experiments, described by the writer in papers and lectures to the Royal Society, the Royal Institution, and the Physical Society between 1882 and 1896, enabled him to explain the Edison effect as follows:—From all parts of the carbon filament, when incandescent, negative electricity is being given off. Some of this passes across the vacuous space in the bulb and charges the metal plate sealed into the bulb. If a galvanometer is connected between the metal plate and the positive terminal of the filament, then it is clear that part of the current from the filament-heating battery has a bye-pass route and flows from the negative terminal

of this battery to the filament, thence across the vacuum to the plate, and so through the galvanometer back to the battery again.

At the same time that the writer was engaged on all these researches two other investigators, Elster and Geitel, had been studying in another way the emission of electricity from hot wires *in vacuo*, and had found that a wire of platinum when not above a red heat, and in a vacuum, gives a charge of positive electricity to a plate near to it, but at a much higher temperature it gives a negative charge.

Moreover, it had been known for some time that in a vacuum tube having metallic electrodes there was some transition resistance from metal to gas which was removed by heating the negative electrode so that with an incandescent cathode a very small electromotive force would send a current through a very rarified gas, whereas without this heating a voltage of several hundred volts might be required to send any current at all.

All these researches were, however, purely scientific, and it is to be particularly noticed that although many of the most eminent physical investigators had directed attention to this subject, no one prior to 1904 had suggested any practical uses of it whatever. A very careful study had been made of this emission of electricity from incandescent wires, now called the "thermionic emission," but no technical application had been made of the knowledge so gained.

In 1904, after careful experiments, I found that a most efficient rectifier of such high frequency currents could be made with an incandescent electric lamp, the filament in which was surrounded by a metal cylinder not touching it, but carried in a separate terminal wire sealed through the glass bulb. If the filament is rendered incandescent negative electricity can pass from it to the metal cylinder across the vacuous space in virtue of the emission of negative electrons from the hot filament. It cannot, however, pass in the opposite direction. This effect is quite independent of frequency, and it affords a simple and most efficient rectifier of high frequency currents. The writer called the device an "oscillation valve," and it has since been known as the "Fleming valve" in wireless telegraphy.

It is used as a receiver as follows: One terminal of the tuning condenser in the receiving circuit of the radiotelegraphic apparatus is connected to the plate or cylinder of a Fleming valve and the filament of the valve is connected through a telephone with the other terminal of the condenser. The valve is generally a small tubular lamp, the filament of which is tungsten or carbon, and can be rendered brightly incandescent by four volts obtained from two storage cells.

When oscillations take place in the receiving circuit the valve permits those movements of electricity to take place through it in which negative electricity is emitted from the filament. Hence it rectifies the trains or groups of high frequency oscillations into gushes of electricity which pass through the telephone all in the same direction. The gushes of electricity come at the same rate as the spark discharges in the transmitter, and accordingly one hears in the telephone a musical note corresponding to the frequency of the sparks at the transmitter. This note is cut up by the signalling key into groups of long and short Morse-code signals. The simple rectifying valve with a cold metal plate as anode and incandescent filament as cathode in a vacuous bulb is called a two-electrode valve and in this form obtained an extensive use as a detector in wireless telegraphy.

Before passing on to note further developments in this thermionic detector it will be an advantage to say a word or two on the crystal detectors, the first of which was made known by General Dunwoody, of the United States Army, in 1906. Time does not permit any lengthy reference to the rectifying crystal detectors, but it may be mentioned briefly that certain crystals, such as carborundum (a carbide of silicon) and molydenite (a sulphide of molybdenum), in contact with metal electrodes possess a unilateral conductivity for high frequency currents, and can be used to rectify oscillation. In the same manner the contact of some dissimilar minerals such as tincite and chalcopyrite, or galena and plumbago possess similar properties, and have been much used as detectors.

The origin of this property is probably thermo-electric, and it is a curious fact that one of the pair is always highly photo-electric as well.

Returning to the thermionic detectors, we may note that in 1907 Dr. Lee de Forest modified the simple oscillation value by introducing a grid or zig-zag of wire placed between the incandescent filament and the plate. The electrons emitted from the filament pass through the holes in the grid to reach the plate. If the grid is electrified negatively to a potential of a few volts it will reduce or

stop the emission, and if it is electrified positively it will increase the electronic emission which forms what is called a thermionic current. The peculiarly valuable quality of the three-electrode valve is that the variation of plate or thermionic current follows exactly the same form as the variation of grid potential, and whether the latter reverses once or ten million times a second the plate current changes strength with equal rapidity and similitude. Since this variation in grid potential can be effected by a suitable transformer the primary of which is traversed by a small current and the secondary circuit has its terminals respectively connected to the grid and to the filament, we can use such a three-electrode valve to magnify or amplify a current or a potential. The instrument, when so used, is called a thermionic amplifier. If used to amplify a high frquency current the operation is called radio-magnification. It can, however, be used also to amplify the already rectified trains of oscillation, which rectification has been effected by a crystal or two-electrode valve, and in this case since the rectified gushes of electricity have a relatively low frequency lying within the range of audition the operation is then called audio-magnification.

A highly important property of the three-electrode valve is that we can employ several of them in series. The plate current of the first valve can be passed through one circuit of a suitable transformer, and the secondary circuit can be connected to the grid and filament of a second valve, and the so increased electric pressure used to vary the grid potential of the second valve. This mode of usage is called "cascade working," and by the employment of three valves in cascade using audio-magnification, it is possible to magnify quite feeble, almost inaudible, telephonic sounds so that they became audible all over a room without the necessity of holding the telephone receiver near the ear. Such cascade arrangement may be possibly utilised to enable those suffering from deafness to hear ordinary telephonic speech on exchange circuits, which otherwise they would be unable to do. Another advance of great value was made in or about 1913. It was found that if an induction coil or transformer consisting of two coils had one of those coils inserted in the plate circuit, and the other in the grid circuit, the arrangement would then spontaneously generate oscillations owing to the re-action of the two circuits on one another provided the circuits are connected up in a certain manner. The reason for this can easily be understood by reference to an old experiment called the "singing telephone." If an ordinary carbon microphone transmitter is joined up in series with a few cells of a battery and with a telephone magneto-receiver, then when the transmitter and receiver are held near, with their diaphragms facing each other, the receiver will generally begin to sing a continuous note. The explanation is as follows: Small sounds in the room fall on the transmitter diaphragm and set it in vibration. This varies the resistance, and hence the electric current flowing through the receiver and transmitter. The receiver then begins to sing or emit a noise, and these airy waves falling on the diaphragm of the transmitter keep it in motion. Hence the receiver and transmitter sustain each other whilst the battery supplies the power. The explanation of the oscillation producing power of the three-electrode valve having coupled grid and plate circuits follows on the same lines. Small variations of plate current create similar variations of grid potential through the coupling transformer and these again in turn enact the plate current.

If the circuits of the coupling transformer are slightly separated, we reach a point at which the system does not of itself produce oscillations, but become very sensitive to any alternating electromotive acting in the grid circuit. This was discovered and employed by Captain H. T. Round, and also by Lieutenant C. S. Franklin to create receiving circuits, employing a three-electrode valve, of great sensibility for wireless telegraphy and telephony.

The oscillation producing thermionic valve has enabled inventors also to make great improvements in "beat reception," or detection of undamped oscillations. The usual receiving arrangements for wireless telegraphy by damped waves are not immediately suitable for undamped waves. If by a crystal detector or Fleming valve we rectify intermittent trains of damped oscillations into gushes of electricity in the same direction having an audio frequency, say, of 300-500 per second corresponding to the spark frequency of the transmitter, then these when passed through a telephone give rise to a shrill musical note which can be cut up by a key in the transmitter circuits into Morse-code signals. We cannot, however, deal thus with undamped waves unless we employ some such device as a "ticker" to cut up the resulting rectified continuous oscillations into regular intermittent currents. We

can, however, do it as follows: Suppose that we couple to the receiving aerial some local source of undamped oscillations such as a high frequency alternator and adjust the speed of this so that it gives rise to oscillations which differ in frequency from the received undamped waves by about 300-500. Then the result will be to produce in the receiving aerial periodic fluctuations of current called beats, which have this difference frequency. These beats can be treated just as if they were intermittent damped trains of oscillations, and can be detected as a musical sound by a crystal or valve *plus* telephone. The difficulty in practice is that high frequency motor-driven alternators are expensive appliances not easily obtained. When, however, it was discovered that a three-electrode valve with coupled grid and plate circuits could generate electric oscillations of high frequency, it was at once seen that this could take the place of the high-frequency alternator, and when coupled to the receiving aerial could generate the necessary oscillations, differing in frequency from the received waves by an amount within the range of audio-frequency. Hence the thermionic valve has now come to be an important implement for undamped wave detection by the above-described method, called "beat reception."

Types of thermionic apparatus especially adapted for oscillation generation have been developed in the United States. One of these called by the not very descriptive name of Dynatron is made as follows: The grid is replaced by a metal cylinder full of rather large holes, and this is placed around a tungsten filament in a high vacuum, which can be rendered incandescent by a suitable electro-motive force. Around and outside of the perforated cylinder is placed another concentric unperforated cylinder, and this is maintained by a battery at a high positive potential of about 200 volts or so relatively to the filament. A stream of electrons, therefore, issues from the filament and passes through the holes in the perforated cylinder and strikes the outer cylinder. These electrons impinging on the said cylinder give rise to other electrons. If the perforated cylinder is maintained at a suitable positive potential it will attract back some of these secondary electrons and so reduce the net electron current flowing to the outer cylinder. It is then possible to adjust matters so that the space between the two cylinders possesses the property that for a certain range of difference of potential between the filament and the outer cylinder, the current decreases with increase of the said potential. This property is the same as that possessed by the electric arc in an ordinary carbon arc, where the current through the arc decreases as the difference of potentials of the carbon increases. This is sometimes called the negative resistance of the arc, but it is better expressed by saying that the arc has a descending characteristic curve. It is well known that if a condenser and inductance are connected across the carbons of an ordinary electric arc, electric oscillations are set up in this condenser circuit. This is the arrangement, due to Duddell, called the Duddell musical arc. It is also the basis of Poulsen's method for producing undamped electric oscillations. The Dynatron, which has a descending or falling characteristic curve or so-called negative resistance within certain limits, can, therefore, be employed in the same way to create oscillations in a circuit having capacity and inductance. It becomes, therefore, a most useful appliance for creating undamped oscillations in an aerial wave either for the purpose of beat reception or as a transmitter in wireless telephony.

A three-electrode generating valve has thus been employed in the production of undamped electric oscillations in wireless telephony by Captain H. J. Round, of Marconi's Wireless Telegraph Company.

For this purpose, as is well known, we have to set up in the transmitting aerial undamped electric oscillations, and then by means of a speaking microphone the amplitude of these oscillations is altered by the microphone to correspond exactly to the wave-form of the speech sounds made to the microphone. At the receiving end another three-electrode valve is employed as a detector, and its plate current passed through a receiving magneto-telephone, the grid potential being varied by the fluctuating, undamped oscillations created by the electric waves picked up by the receiving aerial.

Radiotelephony has thus become an extremely practical matter, and we may expect to see remarkable developments of this art. Ships that "pass in the night" will then "speak to each other in passing," not in messages ticked out in Morse code, but in human speech transmitted over long distances by æther waves, and heard as clearly as if a man were speaking in the same room. Long-distance radiotelephony will require more powerful undamped oscillations made by large high-frequency alternators or by equivalent means, such as Senatore

Marconi's smooth disc discharger or else types of high-frequency alternator.

Transatlantic radiotelephony, as predicted by the writer several years before the war in a Friday evening discourse at the Royal Institution, is a perfectly practical possibility, and, indeed, to some small extent has actually been accomplished by the aid of the thermionic generator. It has been found possible to transmit good clear, radio-telephonic speech a hundred miles or more with remarkably small transmitting antenna currents. The reason for this is the perfectly regular undamped oscillations it is possible to produce with the thermionic generator as compared with the great irregularities of the arc generator. Hence there are no distracting sounds to drown out the speech tones, and we can employ amplifying valve receivers. But there is also a great field for the use of the thermionic amplifier in connection with ordinary wire telephony. Owing to the exactness with which the three-electrode valve repeats and amplifies currents it provides that long-sought desideratum—viz., a frictionless, telephonic relay without a trace of inductance. It has, therefore, been applied as a telephonic repeater for relaying or repeating from one telephone line to another. We can, therefore, by its help counteract the attenuation or loss of current amplitude present in every telephone cable and make the relay take the place of copper in the line. It is known that the experts of the General Post Office are now experimenting carefully with the three-electrode thermionic amplifier as a telephone relay, and find that it gives promise of great value. There is also a field open for it in connection with submarine telegraphy. Accordingly this appliance, which has been developed out of the study of purely scientific phenomena in the incandescent lamp by the present lecturer, and by numerous other inventors, is becoming an invaluable implement in the hands of telegraphic and telephonic engineers of all kinds, and will enable great strides forward to be taken in these branches of electrical engineering. In the Great War, now so happily ended, the thermionic value has played an important part and, perhaps, before long it will be possible to tell the whole wonderful story. Aeroplanes at great heights in the air can now receive communications by radio-telephony and also reply. This feat has been rendered possible only by means of the researches which took their first rise in the investigations of the Edison effect in electric glow lamps, and have finally given us an instrument which may be properly described as one of the master weapons of the telegraphic engineer.

RECENT DEVELOPMENTS IN THE CHEMICAL INDUSTRY IN ITALY.

Before the war there were two electrolytic plants in Italy, those of Caffaro and Bussi, both situated near Pescara in Brescia. When the war began, a third plant was opened by the Government at Rumianca, Province of Novara.

The latest was established at Naples, and work was begun in March, 1918. It is known as the Elettro-chimica Pomilio. The company has been obliged to build its own plant, and almost to create its own machinery.

The main process in the Pomilio works is the decomposition by electrolysis of salt and the resolving of it into its component parts, all of which are utilised. The result is the production of caustic soda, hydrogen, and chlorine (including chlorine derivatives).

According to a report by the United States Consul at Naples, the only raw material used is sodium chloride or salt, which is extracted from the mines in Porto Empedocle in Sicily and is called salgemma. This product is purer than sea salt as regards sulphate content. It is brought in large lumps to Naples by sailing boats and taken in vehicles to the plant 650 ft. from the bay. It is then roughly crushed and dissolved in three concrete tanks, after which the water solution is brought up to saturation (24° to 25° Baumé). To purify its salt further the Elettro-chimica Pomilio uses barium chloride, which precipitates the last traces of sulphate. The barium sulphate precipitated is sold as a by-product.

The works comprise electrical, evaporating, electrolytic, and chlorine compression installation and chlorine derivatives department.

The electrolytic department contains three electrolytic batteries of a diaphragm type of nearly 500 h.p. each. The salt is dissolved and fills a concrete reservoir, from which it is pumped up in a feeding reservoir, whence it is distributed through small glass tubes into the electrolytic cellules in contact with seven graphite anodes, through which the electric current passes. The saturate saline solution is kept in continuous circulation.

The chlorine gas released by the action of the electric current is conveyed through earthenware piping to sulphuric-acid towers, where it is dried by passing over a surface of liquid sulphuric acid. Chlorine is used as such in gas form or is reduced by combined cold and pressure to a liquid state, is transferred into alkaline hypochlorides, or is worked up in other forms of asphyxiating gas.

The residuum of diluted caustic soda is conveyed into large reservoirs, one iron and one concrete tank for each battery. These tanks are situated in a cellar underneath the electrolytical hold,

where the caustic liquid flows by gravity. Both kinds were installed, as it was not known which would best resist the action of the caustic soda content.

The hydrogen is obtained in a very pure state and compressed in a special department into steel cylinders at 150 atmospheres. The cylinders are of tubes, tested to at least 300 atmospheres, and prepared into a process originally patented by Gebrüder Mannesmann, Falk, near Köln. The actual capacity is 75 litres (20 gallons) per cylinder. The very pure hydrogen may be used for airships.

There is an extensive use of rotary pumps at the plant. Electrical motors, pumps, and other appliances are all in duplicate, so as to eliminate any accidental stop.

The Pomilio plant is the most modern in Italy, and the first to be established in Southern Italy, which furnishes an excellent market for caustic soda and chlorine derivatives. It is expected that the improvements introduced by the company in the electrolytic manufacture and working up of caustic soda and chlorine will greatly contribute to the further development of this industry. The company also intend introducing liquid chlorine to substitute alkaline hypo-chlorites for bleaching purposes in paper and textile mills.

THE SUGAR INDUSTRY IN BRAZIL.

The problem of the sugar industry in Brazil is attracting the widest attention among both planters and exporters in that country. No Brazilian industry seems to be in a more precarious condition, due mainly to two reasons—the lack of modern industrial equipment and the need of a highly specialised administration of exportation.

As a remedy for the first condition, writes the United States Vice-Consul at Rio de Janeiro, it is becoming patent to the sugar-growers in Brazil that larger mills, capable of the greatest production and equipped with the most modern machinery, must be substituted for the present small and antiquated types; and that the cultivable portions of sugar land, especially in such localities as Campos, State of Parahyba, must be more fully developed by the introduction of modern agricultural machinery.

In the matter of sugar exportation it is considered of vital importance, in view of the inevitable post-bellum commercial expansion and competition, that means be taken—possibly in a national conference called to discuss the problem —to co-ordinate all activities in this direction. Attention is being called to the fact that the United States is erecting large sugar-mills in the Philippine Islands, in addition to those already in operation in Hawaii and Porto Rico; that Cuba, under the influence of the best of market prices, is developing its sugar plantations proportionately beyond expectation; and that both Germany and Austria will soon re-establish their formerly extensive beet-sugar industries.

TOBACCO-GROWING IN LATITUDE 55° N.

Tobacco-growing at 55° north latitude would seem an impossibility in America, but in the Odense district in Denmark, which lies between 55° and 56°, the cultivation of tobacco has been taken up by many farmers since the war. Travelling across the country, writes the United States Consul at Odense, one sees a surprising number of farms where tobacco is raised and where the drying leaves hang from the eaves of sheds or cottages, or are spread out on frames or ropes.

It would appear to be extremely doubtful, however, whether tobacco-raising has a future in Denmark. Odense tobacco is far inferior in taste and fragrance to imported tobacco, and it is only the difficulty of obtaining the latter that has given an impetus to this new crop. The best that can be said of the tobacco is that it is better than cherry leaves and potato tops, which in a dried form have been considerably used as a tobacco substitute in Denmark. The tobacco is readily prepared for use on the various farms where it is raised. First it is cooked for about ten minutes, then dried and cut, after which it is ready for use.

While most of the tobacco raised is for home use, some growers have taken up the cultivation as a profitable industry. One farmer, on about one-third of an acre, raised a crop of tobacco that brought in over £100. This, however, is an exception; and it seems most probable that the tobacco industry, like other war-born industries, will practically disappear as soon as normal conditions are restored and imported tobacco is again on the market.

MINERAL RESOURCES OF GUATEMALA.

The following account of the mineral resources of Guatemala has been given by the Secretary to the United States Legation in Guatemala, the data being furnished by an expert mining engineer.

There is a large area in Guatemala, principally along the Montagua River, where gold is known to exist in small quantities, and two companies have been organised for the exploitation of this field. One of the companies worked successfully for sixteen years, and recently installed new "washing" machinery, but it is reported that the work has been greatly handicapped by the conditions arising from the war.

The country is rich in stories of silver mines that were worked many years ago, and it is true that formerly Guatemala mined and coined silver. The two places especially mentioned are Huehuetenango and Chiquimula, in each of which are indications of mining operations. At present there are no silver mines in operation in Guatemala, although there are several localities which, it is said, could be advantageously exploited.

Lead deposits are fairly numerous in Guatemala,

principally in the north-western part of the Republic, where there are deposits which will undoubtedly be of commercial value in the future. At present local demands for lead are being supplied by the Indians, who are working some of the deposits. There is also one small company mining lead which employs a blast furnace. This lead occurs in veins in the limestone, and also on the "lime serpentine contact." In general, the lead also carries low silver values, which is one reason why the deposits cannot be advantageously worked under present conditions.

Zinc is found in several places throughout the Republic, but principally in the Department of Chiquimula, where it occurs in replacements in the "altered" limestone, and likewise in contact veins. It is generally associated with lead and some copper.

During the early days of the war, at the time high prices were prevailing, high-grade calamine and zinc sulphite concentrates were exported from Guatemala in small quantities. Together with these were shipped some lead and silver concentrates, which were obtained as accessory minerals.

In other departments of the Republic there are evidences of the exploitation of ore bodies containing zinc, and it is probable that lead and silver likewise were mined in these places.

Traces of copper are found in various sections of Guatemala, but there are no deposits of sufficient importance to warrant commercial development.

There are several deposits of good grade iron ore in Guatemala, but at no place does it exist in bodies of sufficient importance to attract attention at present.

Chrome ore was first found in Guatemala some three years ago, and its exploitation begun, resulting in the development of a moderate industry in that line and the exportation of some 2,000 tons of high-grade ore, the greater part of which was shipped in 1918. The chrome field is said to be quite promising, inasmuch as high-grade deposits have been found in several distinct sections of the Republic.

Limestone is found in great quantities throughout Guatemala. A silicious volcanic ash is frequently found with the limestone, which can be roasted with the lime for the production of cement, resulting in a good grade product.

Coal has been found in small quantities in several places in the Republic, but in no locality as yet has it been mined on a commercial scale. It has been stated, on good authority, that this coal may belong to the Carboniferous Age, and that it might be quite worthy of thorough investigation.

Graphite also occurs in several places in Guatemala.

The existence of mica in the Republic has been known for a number of years, but not until the advent of the high prices occasioned by the war have the deposits been worked to any extent. However, during the past two years a great quantity of mica, in very large sheets, has been exported to the United States, and efforts are being made to continue the exploitation of this mineral.

A good grade of marble has been found in very large quantities, for the exploitation of which a company was formed. This company commenced preparatory operations on a considerable scale, and constructed a railway line to the quarry, but finally were forced to cease operations because of shipping conditions.

Nitre-bearing ground is found in numerous regions in Guatemala, but the principal deposits are along the lower stretches of the Montagua Valley. Several serious examinations of this field have been made, but the exploitation of the deposit on a commercial basis has not yet been attempted. Nevertheless, the natives are working the deposits in their own way, and the bulk of the nitre consumed locally is obtained from this field.

There are several well-known salt springs in Guatemala, which the near-by inhabitants work on a small scale.

Large amounts of sulphur are brought to the market by the Indians, who extract the sulphur from the numerous volcanic craters.

Titanium, mercury, antimony, and molybdenum are all known to exist in Guatemala, but no effort is being made to exploit them, although a good deal of mercury is brought in by the Indians for local sale.

Prospecting presents unusual difficulties in Guatemala, because of the thick vegetation in some places, and the heavy capping of volcanic ash in other places, both of which hide the rock very effectively. It is believed however, that with improved shipping facilities it would prove financially worth while to undertake the exploitation of several of the above-mentioned minerals.

CULTIVATION OF BALSA IN COSTA RICA.

"Balsa," or corkwood (*Ochroma lagopus*), is the lightest wood known, and is now in great demand where lightness of construction is of importance. It is very porous, and acts as a good insulator against heat and cold.

Some particulars of its cultivation in Costa Rica are given by Mr. E. McMillan in *Commerce Reports*, No. 117, Washington. Though the tree grows best in rich ground, it will thrive on almost any ground in the tropics except swamp, but it is a second-growth tree, being found only where the ground has once been cleared. The trunks of the trees are smooth and mottled white and gray. No parasites seem to grow on them, as the boles are perfectly free of vegetation. The leaves of the young trees are very thin and large, often 12 or 14 in. across, and grow on long stems of 18 in. or more. The trees grow separately in groups of male and female, the male being known as "Burrillo" and the female as "Balsa Real." The latter only is now marketable, as the male tree contains too much wood fibre. Both groups are very similar in appearance except at flowering time.

The "Balsa Real" tree blossoms about the third year, in midsummer. From long green pods of 6 in. or more light pink blossoms emerge. Later the pods shrink to about 1 in. in thickness, or half their former dimensions, and about two months after the appearance of the blossom the hitherto erect pod bends and breaks into six sections, which open and reveal quantities of golden-brown cotton that the natives use for pillows and mattresses, often cutting down trees at seed time for this purpose. The seeds cling to the cotton in rows along the sections, about 400 seeds to the pod. These seeds are about the size of a pinhead, 22,500 of them being required to make a pound.

Small vines are the worst enemy of young "Balsa," as the young trees are soft and very sensitive. When the sapling is about 3 in. out of the ground all surrounding weeds should be cleared away. In one year the trees sometimes grow to 10 ft. in height and 4 in. in diameter and to a height of 20 ft. in two years. Until they reach this development they contain too much vegetable matter to be fit for use. A diameter of 10 in. is acquired in five or six years. A five-year-old tree should produce at least 200 board ft., worth about $8 at current prices. Dimensions of logs for market are now 8 to 30 in. in diameter and from 8 to 16 ft. long.

There is a white Balsa and a red Balsa, or "Balsa Colorado" as it is called. The white, "Balsa Blanca," and the red are alike in the flowering season and in general appearance; and in standing timber the difference is hardly apparent, but when cut the dark of the "Balsa Colorado" has a deep red tinge, from which it derives its name. It requires twice as long to dry, and even when dry it is twice as heavy as "Balsa Blanca," having more sap and more wood fibre. Some of the logs have a dark, reddish core, which contains enough sap or moisture to cause decomposition and render them worthless. Logs cut from the lower part of the tree next the root contain a great deal more water than the upper part, but when thoroughly dry are almost as light, and should be just as useful as the rest. When the white wood, or "Balsa Blanca," ages it reddens, colouring from the bottom upward, and at the same time the bark roughens. Trees eight or ten years old are often too heavy for market. "Balsa" logs deteriorate very quickly after felling if exposed to the weather, and borers attack them if they become dry. The logs cannot be cut more than a week or ten days in advance of shipping.

The future of the trade in Costa Rica depends very largely on whether or not Balsa can be successfully grown by planting on land prepared for the purpose, and there are indications that it can be.

Planting can be done 12 by 12 in. apart, and if later this is found too thick the weaker plants can be pulled up. While the rainfall is sufficient for planting thus thickly, it takes considerably longer for the tree to reach marketable size, but when mature it is much taller and freer of branches, besides yielding a larger number of logs. It will take about eight years for trees planted in this order to reach marketable size, and they will then yield logs about 12 by 14 in. in diameter and 28 to 30 ft. long. The Guacimo tract should, therefore, produce 100 trees per acre, with 200 board feet of good log, or 20,000 board feet per acre. The cost of straight planting, including cleaning and preparing the land, lining, circling, and planting (using small plants set out to a stake), and three windrowings to complete cultivation for first year, should not cost more than $10 per acre, as follows: Cleaning and preparing land, $3; circling, lining, and planting, $2; circling and windrowings, $3; 10 per cent. supplying at $0.01, $0.10; overhead and miscellaneous, $1.90. After a period of fourteen months from time of planting, no expenses for cultivating are entailed.

Another and a cheaper method of planting Balsa is to clean and burn the land and scatter seeds where necessary. The work can best be done from January to March; during the remainder of the year it is difficult to burn owing to the constant rains. By this method a grove should be established for a maximum expenditure of $4 per acre. After a year no further work is required.

THE LIKIN TAX IN CHINA.

One of the greatest obstacles to commerce in China is the "Likin," the internal tax on goods in transit, originating as a war tax during the Taiping Rebellion. The "Likin" ("Li," one-thousandth; "kin," gold or money) was originally a tax of one-tenth of 1 per cent. of the value of the goods when it was first imposed, about 1853, but to-day its amount is, apparently, determined arbitrarily by the collector. At the same time "likin barriers" have grown in number, till now they are found at all large towns, and up and down all rivers and thoroughfares. Between Canton and Wuchow there are no fewer than six of these barriers, each involving payment of duties, delay, and worry, vexatious, if not ruinous, hindrances to the free flow of trade.

It has been stated that the constant repetition of the tax is primarily responsible for the high price of Chinese tea. Starting with a cost of 5 cents per lb. at the point of production in the interior, when the seaport is reached, after passing several of these barriers, it is worth 50 cents per pound. According to a report on the subject by the United States Commercial Attaché at Pekin, the explanation offered by the likin officials is that the revenue is necessary for the upkeep of the Chinese Army. It is usual for both collectors and merchants to ignore the official tariff, and to settle the likin by a system of barter.

Foreigners have the advantage over natives in that by treaty they can pay a tax of 2½ per cent. *ad valorem* at the port of entry, in addition to the regular customs duty of 5 per cent., and thereby secure for their goods exemption from further

taxation in transit to the interior; and if the interior destination is a treaty port, they can send them there without paying the additional 2½ per cent. Some native guilds have succeeded in making agreements with the officials whereby they pay, say, 3 per cent. at the point of departure and 2 per cent. more at each barrier, but the vast majority of traders must make arrangements with each collector. Total likin payments on a cargo carried a considerable distance may easily amount to more than the original value.

China officially recognised the evils of the likin system in Article VIII. of the Mackay Treaty with Great Britain, signed in September, 1902, and agreed to abolish the likin barriers in return for permission to place a surtax on foreign imports and exports and a consumption tax on Chinese goods not intended for export; but as the consent of other foreign Powers was necessary to the enforcement of this provision, it has not come into operation.

The abolition of the likin is complicated by the fact that the likin revenues of certain provinces are pledged under foreign loans, and certain amounts are remitted to Peking for specific purposes. It is to the interest of the Chinese, as well as of other nations, that some way be found to reform, if not to abolish, this handicap to Chinese commerce.

MANUFACTURE OF SEDGE MATS IN THE PHILIPPINES.

There is an opportunity for capital to establish a new industry in the Philippines in the form of the manufacture of sedge mats, similar to those which for some time past have been made in large quantities in Japan and Formosa. The Philippine article, which will serve every use to which the Japanese mat is put, is made from the common sedge plant known as balangot (*Cyperus malaccensis* Lam.). The making of these mats is now confined principally to the industrial division of the Bureau of Education and the households into which the industry has been introduced, for the most part through the children of the schools.

Owing to lack of organisation in the industry, the balangot mat has not hitherto been made in commercial quantities. Like the Philippine embroidery industry a few years back, the mat industry of the islands, as a commercial proposition, is purely potential. Philippine embroideries were put into the channels of commerce by a few pioneer American organisers, aided by the Bureau of Education. Centres of manufacture were organised; capital was supplied to attract workers; a combination of the factory and household system of production was established; salesmen were sent to the United States, and a systematic canvass for orders was made in some cases. When this had been accomplished, the making of Philippine embroidery immediately took rank as one of the leading industries of the islands.

According to a report by the United States Commercial Agent at Manila, the time appears to be ripe for some such vivifying of the Philippine mat industry. The materials are at hand in abundance. The market is undoubtedly waiting. For the present at least mat making is among those industries that must rely on handwork. Machines may, in time, be invented to do the work, but that will not happen until the industry has been well established by handworkers. The missing factor is the organiser, some one to supply the money and the executive skill necessary to bring and fuse together the elements of the industry.

Balangot is plentiful in almost every part of the Philippines in lowland, swampy regions, and along brackish tidal waters. It grows to the height of about 3 ft. The balangot stem is used for different articles, either in whole or split into two or three parts. The rough edges of the split straws curl inward when dried in the sun. The straws are used at present in the making of slippers, hats, hand-bags, and similar articles, in addition to mats and matting. Sufficient interest has already been manifested in this product to warrant an effort to manufacture it on a commercial scale, but the establishment of the industry is a task to be undertaken only after a careful preliminary survey of the field. Data are lacking as to the cost of gathering the balangot, the quantities available in the different localities, the location of the material with respect to transportation; in short, the cost of production of the finished product as compared with the cost of production of the article now being imported from Japan and Formosa, with which the Philippine product would have to compete.

AMERICAN IRON AND STEEL SITUATION.

It is believed, reports H.M. Commercial Secretary, U.S.A., that the action of the United States Shipping Board in granting a low rate on railroad equipment to South Africa will be followed by other concessions, so as to help American manufacturers to extend their foreign trade.

Shipments on recent orders placed by the Government of the Netherlands included 800 tons of steel forgings, while 23,000 tons of bars, plates, shapes, etc., are expected to be shipped immediately, and a further 8,000 tons of rails are to follow soon.

An order for 800 steel mine cars for the Dutch East Indies, to be used in mining tin, has recently been placed with a Cleveland company. The general impression is that the sales of foundry and malleable iron for June exceeded the amount of business done in any month this year.

It is interesting to note that the June pig-iron output shows definitely the turn in the iron industry in the United States. For June the total output was 2,114,863 gross tons, or 70,495 tons a day, against 2,108,056 tons in May, or 68,002 tons a day. Seventeen furnaces blew in and twelve actually blew out during the month, thus showing

a gain of five furnaces. The estimated capacity active on July 1st was 71,700 tons a day for 200 furnaces, as compared with 68,600 tons a day for 195 furnaces during last month.

It is expected that the gain of 2,500 tons a day in production during June over the average in May will have been carried further during July.

It is the general impression that in steel and iron the month of June has witnessed a distinct turn for the better; the manufacturers now report a much more encouraging prospect. Operations of steel plants generally show increases. Pig-igon plants which were idle in April are now operating, and others are making preparations to begin operations. Large orders for steel rails have been placed by the railroads, and inquiries for a large amount of steel tonnage for export trade are appearing.

Even in those districts where the pig-iron trade is slightly smaller, and where plants have not yet resumed their activity, there is nevertheless a more hopeful feeling than hitherto. Foundries and cast-iron pipe makers are also running more steadily.

The fuel situation has been, however, much below normal so far as production is concerned since the beginning of the year, and the bituminous market is dull, but there is an increasing demand, due, no doubt, to a reduction in stock, and also owing to the fact that industrial consumers are coming to the conclusion that a tight situation in the production of coal will exist next winter. A great deal of high-grade bituminous coal is now said to be covered by contract up to next April. A very large demand for anthracite coal for next winter is also predicted.

It is reported that coal mines have been producing far below capacity, and there is, so far, every possibility of a shortage. The production of beehive coke during May was 1,135,840 tons, as compared with 1,316,960 tons during April, the market prices being a little above the actual cost of production.

It is reported that in the Pittsburgh district millions of dollars are now being spent in repairs and enlargements by steel companies, which is interpreted to mean that prospects of great expansion are in sight. Buyers are now willing to accept present levels of prices in steel, and are prepared to close tonnages at prices existing at present to a more forward date than the producers have heretofore been willing to entertain.

Steel is now being sold in the first open market since the beginning of the war, and there is a large demand for structural steel. So far as can be ascertained, wire plants are now operating at about 85 per cent., while pig-iron plants in the Pittsburgh district are on a basis of from 65 to 70 per cent. Operations are carried on at about 50 per cent. of capacity in both zinc and lead. In common with the steel industry, manufacturing has taken a strong upward turn.

JAMES WATT CENTENARY.

The centenary of the famous inventor, James Watt—born 1736, died 1819—will be commemorated on September 16th, 17th, and 18th, at Birmingham, where he spent the best part of his life, after laying in Scotland the foundation of his greatest achievement. The proceedings will open with a service in Handsworth parish church, his burial place, after which a visit will be paid to Heathfield Hall, his home from 1790 till his death. On the second day there will be lectures dealing with the application of science to industry, and visitors will be shown two Watt engines in the vicinity of the city, one at Ocker Hall and the other at Bordesley. The arrangements for the same day also include a Centenary dinner. On the third day more Watt engines will be on exhibition, and the University of Birmingham confers honorary degrees upon distinguished engineers and scientists. Many relics of Watt, of his partner, Boulton, and of their contemporary, Murdoch, who made the first gasholder, will be on view each day. Some twenty universities and numerous societies and institutions are represented on the general committee, of which the Lord Mayor of Birmingham is President, and Mr. William Mills, M.I.Mech.E., Chairman. The official representative of the Royal Society of Arts is Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. As a permanent international memorial of Watt it is proposed (1) to endow a Professorship of Engineering to be known as the James Watt Chair at the University of Birmingham, for "the promotion of research in the fundamental principles underlying the production of power and the study of the conservation of natural sources of energy"; (2) to erect a James Watt Memorial Building, to serve as a museum for collecting together examples of the work of Watt, Boulton and Murdoch, and as a meeting place for scientific and technical societies; and (3) to publish a Memorial Volume.

CORRESPONDENCE.

SCIENTIFIC AGRICULTURE IN INDIA.

The enclosed account by Sirdar Darshan Singh, Assistant Director of Agriculture, Punjab, of the work on his experimental farm at Hansi, Punjab, is so interesting that I think it would be worth publishing in the Society's *Journal* as a proof of the great benefit of the application to agriculture in India of Western methods and of the success of home scientific training for young Indians.

Sirdar Darshan Singh was a very successful pupil at the Agricultural College, Cirencester, taking first-class honours in each subject, I believe. He is son of a chief with considerable property, and is a relative of the great spiritual leader of the Sikhs—Bedi Khem Singh. W. Coldstream.

The extract referred to is as follows:—"It is hard to cope with the prejudices of people and long-standing customs, but I am glad to say that

with sympathy and careful manipulation I have been able to convert many Zamindars to the new ideas of agriculture, in spite of their poverty and conservatism. For example, when I took over charge there was no cotton grown in Ferozepore district, not even country cotton, and by patient efforts I was only able to grow about 500 acres on Zamindars' land last year. Now I am glad to say that this year I have over thirty thousand acres under American cotton in that district, and that also mostly in lines (a new system at any rate in this country). The 500 acres last year were a good practical demonstration. Now the economic value of this change is tremendous. Taking it at a low figure of 10 maunds (800 lb.) an acre, and at Rs. 15 per maund, it works out at 4½ lakhs (£30,000), and at an average figure of 12½ maunds an acre at Rs. 20, it works out at 7½ lakhs (£50,000). My selection of Desi (country) cottons has also come at the very top this year, and there is tremendous demand for its seed this year. The wheat grown at our farm was splendid, and the average outturns on the whole farm are over four times what Zamindars get in their lands, and in certain fields the produce was six times the Zamindars' average. These are of course only some of the branches of work."

GENERAL NOTES.

Fuel Economy.—The autumn meeting of the Iron and Steel Institute will be held in London on September 18th and 19th. The proceedings will include a general conference on Fuel Economy, at which the following reports and paper will be read: "Report on Fuel Economy in Steel Works," by Dr. W. A. Bone, Sir Robert Hadfield, Bt., and Mr. A. Hutchinson (presented on behalf of the British Association Fuel Economy Committee); "Report on Fuel Economy in Foundry Practice," by Mr. H. J. Yates; and "Fuel Economy in German Iron and Steel Works," by Messrs. Cosmo Johns and L. Ennis.

Meeting of Orientalists.—A joint session of the Royal Asiatic Society, the Société Asiatique, the American Oriental Society, and the Scuola Oriental, R. Università di Roma, will be held in London on September 3rd and the three following days, under the presidency of Sir Mortimer Durand. The arrangements include a visit to the Oriental Rooms in the British Museum, with exposition by Mr. Longworth Dames and others. At another meeting gramophone illustrations of Indian dialects will be given by Sir George Grierson.

Diamond Discovery in the Gold Coast.—An interesting discovery of diamonds was made in the Gold Coast early in February last by the Director of the Geological Survey (Mr. Kitson). The stones occur in shallow quartz gravels of the Abomo stream and adjacent ridge, near the village of Abomoso, Birrim River, at about 15 miles N.W. of Kibbi, in the district of Akim Abuakwa, and some 65 miles to the N.W. of Accra, the capital of the Colony. All the stones found up to the present time are small, averaging approximately 30 to the standard carat, the largest being about one-fifth carat. Most of them are of good quality—clear and colourless—while many are perfect crystals. In value they vary from 10*s.* to 12*s.* per carat for the smaller grade; 17*s.* 6*d.* per carat for the medium grade; and 30*s.* to 32*s.* 6*d.* per carat for the larger grade. This is for mixed samples, including all qualities of stones. Some of the largest stones, however, are worth from 70*s.* to 80*s.* per carat. Upwards of six hundred diamonds have been found merely by panning during the time the surrounding locality was being tested with regard to the origin and distribution of the diamondiferous gravels. Sufficient work has not yet been done to prove the economic value of the discovery.—*Board of Trade Journal.*

The Cocoa Production of the Empire.—Among the products of the Empire which before the war were not utilised in this country to the extent that they might have been, cocoa takes a prominent place. The quantity of cocoa produced in British countries in 1913 was more than three times the amount consumed in the United Kingdom, yet this country only obtained about one half of its supplies from those sources, the remainder consisting largely of South American cocoa and foreign cocoa shipped *viâ* Continental countries. Not only was this the case, but we were importing large quantities of prepared cocoa and chocolate from foreign countries, which had been manufactured there from British-grown cocoa. During the war the position improved, and a much larger proportion of the raw cocoa was supplied from the Empire, no less than 86 per cent. of the total imports into this country coming from British possessions in 1917, and it is be hoped that this state of things will continue. The importance of the matter will be realised when it is stated that in 1916 the total imports were valued at no less than six and three quarter million pounds sterling. The question of the production of cocoa in the different countries of the Empire, the world's consumption, and the cocoa trade of the United Kingdom, is fully discussed in the *Bulletin* of the Imperial Institute. Of the many interesting points brought out, two call for special mention. The first is the unprecedented growth of the cocoa industry in the Gold Coast, where the product is grown and prepared for the market entirely by the natives. The colony began to export cocoa in 1891, and it now produces more than one quarter of the world's output. The other equally remarkable fact is the enormous increase in the consumption of cocoa in the United States in recent years. The consumption has trebled since 1913, and about one half the total quantity produced in the world now goes to the States.

THE MOTOR INDUSTRY IN AMERICA.—In the United States, says the *Board of Trade Journal*, motor vehicles have come into such general use that there is one for every 18 persons in the country. At the beginning of this year the cars and commercial trucks numbered 5,945,442, and had increased by 20 per cent. since 1917. During the past eleven years America imported from us 881 passenger cars and sent us 41,182. The rich and extensive upper class in New York, as well as the very large number of the newly-rich, should provide a sure market for the sale of any English car of undoubted distinction. It is probable that most purchasers would elect to buy the chassis only. The question of the use of the roads for the haulage of goods is being taken up seriously throughout the States. Express motor trains run out of most of the big cities to the farms within a hundred miles. It is expected that the railway short and middle distance hauls will soon be things of the past.

INDIAN FLOSS FOR LIFE-BELTS.—During the war the proper provision of life-belts and other life-saving appliances on ships became of vital importance owing to the submarine menace. One of the most widely used appliances was a life-jacket stuffed with "kapok" or floss. This floss has very great buoyancy, a jacket containing 24 oz. of the fibre being capable of supporting an adult in the water. According to the existing official regulations, the only kapok that may be used for this purpose is Java kapok, and consists of the long hairs surrounding the seeds of a tree which occurs abundantly in the Dutch East Indies. A similar material is, however, obtainable from India, but from a different tree, and this Indian floss cannot under the existing regulations be used for life-jackets. The results of trials made at the Imperial Institute, details of which are given in a recent *Bulletin* of the Institute, have shown that the Indian floss can fully satisfy all the requirements as regards buoyancy and freedom from water-logging. It is, therefore, suggested that the use of Indian kapok should be officially permitted for life-jackets. Inquiries made by the Imperial Institute showed that kapok, equal in quality to that used in the trials, is available in India in large quantities.

DAIRY FARMING UNDER SMALLHOLDING CONDITIONS.—The latest booklet issued by the Board of Agriculture in its useful series of Guides to Smallholders is entitled "Dairy Farming under Smallholding Conditions." This booklet has been specially prepared for ex-Service men, but it will also be found useful by other would-be smallholders. It deals with such questions as the choice of a holding and the different systems of dairy farming. It also discusses the relative advantage of milk selling, cheese-making, and butter-making, and gives detailed instructions for making cheese and butter.

THE RATS BILL.—Some ten years ago Sir James Crichton Browne estimated the yearly damage done to food by rats, in England alone, at £15,000,000. The value of that quantity of food to-day would of course be immensely higher. In the rush of work on the farm, which during the war had to be done with diminished labour, rats have multiplied. The Government have decided to deal with the evil by legislation; the Bill recently introduced makes it a duty of every occupier of land or of buildings to keep the property free from rats or mice. Any person who fails to take such steps as may be necessary and reasonably practicable for the destruction of rats and mice on any land of which he is the occupier, or for preventing such land from becoming infested, will be liable on summary conviction to a fine not exceeding £20. A vessel is to be treated as land, and the master as the occupier; it is his duty to prevent the escape of rats or mice from his ship. The Act will apply to Scotland and Ireland as well as to England.

APPLE APHIDES.—The disease of apples, commonly known as aphis, dolphin, or blue bug blight, is at times a source of serious loss to fruit-growers. It is caused by one or more of eight different kinds of plant lice or aphides, but by far the greatest damage is due to four only. These are (1) the blue bug or rosy apple aphis; (2) the green apple aphis; (3) the oat apple aphis; and (4) the woolly aphis or American blight. The first three of these aphides are dealt with in Leaflet No. 330, which has just been issued by the Board of Agriculture. After pointing out the characteristic nature of the damage done by each of the aphides, the leaflet traces briefly their life histories, and finally suggests treatment for destroying the pests. The only satisfactory method is to use a suitable spray, and recommendations are given as to the best times to apply the sprays and how to make them.

CANALISATION OF THE RHONE.—A Bill for the canalisation of the Rhone and the employment of water-power is now before the French Chamber of Deputies. The cost of the scheme is estimated at 2,500,000,000 francs (£100,000,000), and the total power to be obtained will not be less than the equivalent obtained from 5,000,000 tons of coal, or one-fifth of the coal production of France for 1918. More than 250,000 hectares (617,785 acres) will, as a result of the irrigation project, be available for intensive cultivation. The canal will be accessible to vessels of 1,200 tons. It is estimated that the scheme will take fifteen years to complete. The shares will be guaranteed by the State.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—August 22, 1919.

No. 3484. AUGUST 29, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,484. VOL. LXVII.

FRIDAY, AUGUST 29, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

GAS AS A SUBSTITUTE FOR PETROL AND PETROLEUM PRODUCTS.

In November, 1917, an Inter-Departmental Committee was appointed to consider (1) The employment of gas in substitution for petrol and petroleum products as a source of power, especially in motor vehicles, and the manner in which such gas may be supplied, stored, carried and used with due regard to the safety of the public; (2) the action, if any, which should be taken by His Majesty's Government to encourage and safeguard the use of gas for this purpose. In April, 1918, the Committee submitted an interim report. The final report is dated June 30th, 1919, and has been issued as a White Paper [Cmd. 263].

The following is a summary of the principal conclusions:—

Gas traction is fully as safe as any other system of mechanical traction, even when exposed and unprotected flexible containers (gas-bags) are used.

Gas traction in its newer forms of application merits adoption as a commercial alternative to electric, petrol, or steam traction, more especially for the propulsion of motor omnibuses and other commercial types of road motor vehicles, including tramcars.

The average traction equivalent of one gallon of petrol is 250 cubic feet of ordinary town-gas.

Flexible containers will be generally superseded by semi-rigid and rigid containers, wherever compression plant can be installed, but it is inexpedient, having regard to the uncertainties which surround the future of liquid-fuel supplies in relation to prospective world-wide demands, that any existing facilities for gas-traction service should be either abandoned or dismantled.

In the event of an attempt to establish a monopoly of motor spirit, any consumer for traction purposes of not less than 80,000 gallons a year has the commercial alternative, where supplies of town-gas cannot be obtained at a moderate price, of making his own gas.

Semi-rigid containers made of rubber and canvas are unsatisfactory, but semi-rigid containers made of an inner rubber bag suitably restrained by an outer member of woven steel-wire with metal end-plates, and complying with approved specification, appear to be satisfactory for internal pressures not exceeding 45 atmospheres, although results of endurance tests in service are not yet available.

The time has come to approve and encourage the use of metal cylinders, made of high-carbon or certain alloy steels, to contain combustible gases at high pressures for traction purposes, and such metals can now be safely so employed for working pressures up to 2,250 lb. on the square inch.

Subject to the adoption of the simple precautions specified, there is no risk of explosion with town-gas during its compression into cylinders or its use from them.

Wire-wound metal cylinders with removable ends held in place by screwed tension-rods lose gas at the joints after the earlier stages of discharge, and are heavier for any given volume of gas than plain cylinders made of high-carbon or alloy steels.

The cost of compressing town-gas into cylinders, inclusive of maintenance of compressor plant, storage-cylinders and vehicle-cylinders, and of interest and depreciation on the capital sums required, will vary between 1*s.* 8*d.* and 3*s.* per 1,000 cubic feet of free gas, according to quantity required and working pressure adopted, the total cost involved being on the average equivalent to 7*d.* per gallon on any petrol replaced.

Satisfactory pressure-reduction systems are available to effect the requisite automatic control of gas at high pressures to meet road-transport conditions for either passenger-carrying or goods-carrying vehicles.

The highest mechanical and thermal efficiencies under road-transport conditions of working can be attained by average drivers when there is a non-variable air-admission area and the volume of air after initial setting is controlled solely by the travel and speed of the engine-pistons, the only hand-regulation during running being that of the gas-admission (not air and gas).

The relative power-yields that are obtainable from an ordinary motor-vehicle engine, unaltered structurally as regards the compression-space, may on the average be accepted as:—

When working on petrol	100
When working on town-gas of 450 B.Th.U. (gross) per c. ft.	91

When working on suction producer-gas (partly hydrogenated with water-gas) of 210 B.Th.U. (gross) per c. ft. 87

When working on suction producer-gas of 140 B.Th.U. (gross) per c. ft. 82

Portable suction-gas producers are available of types adapted for the propulsion of commercial goods-carrying vehicles; such plants, after the necessary attention at lighting-up, can be made to function automatically, their fuel cost, with coke at 45*s*. per ton or anthracite at 55*s*. per ton, is equivalent to petrol at 5·4*d*. per gallon, one cwt. of coke or anthracite will on the average do the same work on the road as 5·6 gallons of petrol, and the weight of generator and accessories for a 30-B.H.P. engine is about 220 lb.

The risk of escape of unburnt carbon-monoxide gas from a suction-gas plant in a motor vehicle is not such as to call for the exercise of special precautions except while the vehicle is at rest overnight within an enclosed structure with the fire still burning in the producer.

The water-feed to a portable suction-gas producer can be so adjusted as to increase the calorific value of the issuing gases by as much as 50 per cent. on a consumption of water falling as low as 25 per cent. by weight of the simultaneous consumption of anthracite or coke.

Importance has, heretofore, been attached by motor-vehicle users to the relative calorific values of combustible gases, instead of to those of mixtures of such gases with the requisite volumes of air, in forecasting the respective power-yields on their internal combustion.

Suction-gas, employed alone or partly hydrogenated with water-gas, should in the near future prove a suitable alternative fuel for use in any internal-combustion engine primarily designed to run on alcohol.

Physical difficulties of storage and conveyance in conjunction with allied considerations of cost render the use of liquefied hydrogen, methane, carbon monoxide, or ethylene, which gases are or may shortly become available for liquefaction on the large scale, commercially impracticable for traction work.

There is an increase of weight when an absorbent material is introduced, compared with that when cylinders containing only gas under compression are used, for any given volume of free gas, and no saving in the total cubic space occupied.

The necessary extra provision to utilise systems for enriching gas in any vehicle does not yield commensurate advantage, with possible but as yet unproved reservations in favour of the use of acetylene or naphthalene.

The recommendations are

1. The national importance of ordinary town-gas as a home-produced and distributed fuel for power and traction purposes should now be brought within the official cognizance of all Departments of Government, both central and local.

2. There should be all possible Departmental and Local authority encouragement and provision for the extension of gas-power and gas-traction facilities.

3. No restrictions or regulations other than those that may be necessary to ensure compliance with the terms of the report should be placed upon the drawing of gas for traction purposes through suitable meters at consumers' premises or private filling-stations, subject to the sufficiency of local supplies of gas.

4. Rotary meters should be tested with a "flying" start and their use approved if they are accurate within 2½ per cent. plus or minus while capable of passing gas.

5. Sections 12 and 13 of the Sales of Gas Act, 1859, should be so amended as to give certain new powers to the Board of Trade with reference to gas meters.

6. No regulations that are not equally applicable to petrol-driven vehicles should, as regards access to public wharves and warehouses, or the estates and premises of dock and harbour authorities, be applied to gas-propelled vehicles which are equipped to run on compressed gas.

7. The circulation of motor traffic by means of power derived from self-contained, portable, suction-gas plants should be approved by the Fire Offices Committee.

8. The use of semi-rigid containers made of an inner bag of rubber and an outer casing of woven steel-wire with end-plates of solid metal, if constructed and tested to the specification, should be permitted for working pressures up to forty-five atmospheres.

9. Any cylinder or cylinders to contain gas under compression should, when fitted in a vehicle for traction work, be disposed within and be totally enclosed by the bodywork or other substantial material of the vehicle-structure.

10. Any cylinder or cylinders fitted in any vehicle to contain gas under compression for traction work should by preference be recharged while in position in the vehicle.

11. No individual, firm, company, or other undertaker, should be allowed to compress gas for traction purposes, or to supply or charge cylinders for such purposes, except after notification to and registration by the Ministry of Ways and Communications.

12. The use of cylinders of carbon or certain alloy steels, made to comply with the specification, should be permitted in traction work for internal pressures up to 2,250 lb. on the square inch, and the Committee's specification should now in respect of such purposes replace that of the Home Office Committee of 1895.

13. The safety-valve on the charging side of any compressor, on its use for the delivery of gas to cylinders for traction purposes, should be set for not more than 5 per cent. excess of the actual working pressure approved for the particular service, and under no circumstances for a pressure

higher than seven-tenths of the test pressure marked on the cylinder.

14. There should be provision at any compressing installation to ensure that air is not drawn into the compressor with the gas, and other precautionary measures should be based upon the model set of regulations given in an appendix of the report.

15. Piping, joints, reducing-valves, gauges, and other control fittings and accessory parts should comply with the general recommendations in the report, but the Committee consider it to be unnecessary to lay down hard-and-fast rules on points of detail other than a standard connection, which should be cut to five-eighths inch British standard pipe thread.

16. A vehicle deriving its power from a portable, self-contained, suction-gas producer should not be housed under living-rooms in human occupation, or while the fire is alight be stored overnight in the same building or enclosed structure as a petrol-driven vehicle.

CONFERENCE OF RESEARCH ORGANISATIONS.

A conference of Research Associations was held at the offices of the Board of Education on July 29th. There was a numerous and representative attendance.

In the unavoidable absence of the Right Hon. H. A. L. Fisher, M.P., who was to have presided, the proceedings were opened by Sir William S. McCormick (Chairman of the Advisory Council on Scientific and Industrial Research). He said that the reason for calling the meeting was that one or two matters had cropped up which they thought would be very much better discussed than written about. The first of these was the formation of a Records Bureau. The second head was with regard to the conditions of employment of research workers by Research Associations. One of the great difficulties which the new Research Associations were finding was that they had not at present sufficient scientific workers to go round. They were doing their best in the Department to encourage research workers, to encourage the universities to train research workers, and by a scheme of assistance through what one might call scholarships and fellowships. But that was not all that was required. They must assure to a research worker that he would earn such emoluments as would enable him to have a life free from financial worries. The third head, co-operation amongst Research Associations for the study of accessory materials or equipment, was one that had presented itself in the course of the work of the Research Associations already formed. With regard to the fourth head, subscriptions to Research Associations, that was a subject which, of course, they had to deal with in the formation of the Research Associations themselves, but there were certain questions which he thought they should want to consider concerning that also.

Records Bureau.

Mr. Fleming (British Westinghouse Company) said he supposed that all who had to do with industrial research had at some time or other realised or wished for some all-embracing scheme by which they could secure the available knowledge about the department they were dealing with, and had conceived how such an organisation could be set up; but whether it was expedient in the present, should they say undeveloped, state of industrial research to initiate such a scheme on international lines was a matter of very grave doubt. He thought that in the Memorandum which the Department had just prepared, relating to the question of the formation of a Records Bureau, they had adopted the very wise policy in the first place of limiting their efforts to what they could economically handle to make sure that their information was reliable, and of dealing with that particular part of the problem efficiently. He should rather have liked to see some extension of this work, which was at present to be confined, as he understood, to the handling of records principally from Research Associations. In addition to becoming a records office for the fruits of industrial research from these different associations operating as finished records, he should like also to see some attempt made to collect the side lines, should he say, of research. These very valuable data, which often arose in the pursuing of some research to a conclusion and which might be only incidental to the research itself, were often of a very fleeting kind, and unless they were recorded in some fashion might be lost altogether. It was often extremely valuable information, and so he conceived an organisation such as was proposed dealing also with other things. He conceived that the Bureau might be a very valuable thing indeed and help in educating the public, particularly if it could be linked up with what might be termed the intelligence section of each research organisation, because the bulk of the information of research would come from industries and from those who were most closely in contact with industries, each being a potential accumulator of information. With regard to the proposal to deal with the indirect, or incidental, features of information, he was a little in doubt as to the advisability of this. Provided it was confined to dealing with information from, say, overseas research organisations, or research or other Government organisations, he should think it might be a very good thing; but there was a grave risk in launching out and forming a central bureau extending to work of that kind of making it instead of a live intelligence department really a dead museum. With respect to the other proposals, such as those dealing with the question of materials, by-products, and so on, work of that kind was extremely desirable, but it was secondary. One of the most important of the needs seemed to him to be any means which would serve to link up those persons who were engaged in industrial research. Both for geographical and

other considerations research workers in associations could not participate in any corporate life, and, therefore, they lost one very great and very potent asset in that they did not get that personal inspiration that came from personalities meeting together when they were co-operating or working on the same lines. He would urge that not only should means be taken to enable directors of research to come together and meet the officers of the Department, but that all conceivable means be devised to bring every industrial worker as far as possible into contact with the big bodies of other industrial workers. There were two great advantages in that: one was that it tended to do away with the secrecy which was, he thought, still a hampering influence in industrial research work. During the war some of that secrecy disappeared: they welcomed others to their works, and they co-operated with them when they were under the common menace. They were still under a common menace, and he thought that everything possible should be done to cut out that element of secrecy. He would like to see an inquirer for information brought into relations with the man who could supply it. He was usually not necessarily the director of research, but a man further down. Then when they looked at the needs of industry at the present moment they were faced with shorter hours and higher cost of production on account of labour, and they had to get over these difficulties in some way or other. He thought that for a long while to come a great deal of the research performed in industry would be conducted more and more along lines of solving those problems incidental to improving processes and methods and the toning up of efficiency generally, and the research knowledge relating to that sort of thing existed only in the minds of men, and there was very little written about it. He, therefore, urged not only that the Department but also the Research Associations should assist in all practicable ways towards bringing research workers into close contact. There was one other point in the Memorandum which struck him very much, and which he very cordially supported, and that was the question of education, the educative influence of any means which could be taken by this Bureau in enlightening public opinion. They had not only the employer and the employee, but they had also the consumer to consider, and each had his responsibility in encouraging research. With tendencies more and more towards State aid and State control, that necessity became even more urgent, and they must, he thought, bring home to every one that he had a responsibility in solving this great economic problem.

Mr. Reason (Birmingham, Non-Ferrous Metals Research Association) said the British Foundrymen's Association were anxious to know how far they could be of assistance to any Research Association which was formed in connection with the iron-foundry industry and in what way they could become allied to it.

Major Bliss (Woollen Research Association) said that here we were not in the same position as people in Germany, in having really good technical libraries in all the provincial cities. At Manchester there was a very fair one; but speaking generally the Patent Office was the only place at which many journals could be seen. He thought that if such a Bureau as was suggested was formed, provision should be made by which a reference could be sent to the Bureau and a copy of a paper or an extract from a paper obtained, because it was a very great waste of time and money to have to send a man all the way to London to look up perhaps a couple of pages in a journal.

Mr. Beck (Scientific Instrument Makers' Research Association) said that in the formation of that Association it was pointed out that the results of research would be retained for the benefit of its members, except in cases where the Department might decide that it was of national importance that they should be disclosed. He should like to know the method which the Department thought it would be advisable to adopt in order to safeguard the interests of the associations who were at the present time, to his own knowledge, disclosing a great many facts which they would not otherwise disclose, with a view to benefiting the industry to which they belonged. That also raised the further point as to what precautions would be taken to prevent the information obtained, and placed in the Bureau, from getting into the hands of competing companies of different nationalities.

Mr. Williamson (British Scientific Instrument Makers' Research Association) asked whether the expenses of the Bureau would come out of the funds of the Department or be provided for by a special grant in another way? It was obvious that if the Bureau grew to very big dimensions it might make a large inroad indeed on the financial side. They would like to have some information, therefore, as to the magnitude of the Bureau which was contemplated.

Mr. Heathcote (British Non-Ferrous Metals Research Association) was sure that if the Bureau could secure for research workers the sight of original works it would be a very great advantage. He had heard that the free libraries would soon be under the Board of Education. He had no authority for saying this, other than that he had heard something about it. It would be a very great advantage if periodicals and books which were at present housed in certain libraries could be taken to the actual inquirer with the help of this Department.

Mr. Marlow (Boot and Shoe Research Association) said that in his industry the most valuable information could be obtained from America. They found that the Research Associations of

America have or had the system of declining to give any information until it was two or three years old. He did not know whether there could be any interchange through this suggested Records Bureau by which they could get quicker information from America.

Sir FRANK HEATH (Secretary of the Department of Scientific and Industrial Research), in replying to the discussion, said: "Mr. Beck mentioned the very important question of the ownership of results by Research Associations. We fully recognise that. We have declared officially that the ownership in scientific results is that of the members of the association—the association holds that property in trust for its members. Accordingly, the Records Bureau will be organised in two sections, a confidential section and a non-confidential section. We shall ask research organisations, in forwarding us information, to indicate which part of the information they consider confidential and which they do not consider confidential; and any information in the confidential section of the Bureau will be communicated to nobody at all without agreement with the body that sends it. We shall take the utmost care about that. In fact, the confidential section of the Bureau will merely be the collection of that information which is held confidentially by the Department in its ordinary course of administration. But Mr. Beck realises, as we all realise, that sometimes this confidential information may be of great value to another research organisation, and it might be quite easy to negotiate the transference of that information to another association on reasonable terms. The Department will then act as the 'honest broker' for the transference of this information; but you may absolutely rely upon it that there will be no breach of that confidence. The section will be absolutely watertight, and nothing from that section will be used except in consultation with the body or person sending it to us. We shall have to observe that not merely with regard to Research Associations, but with regard to other research organisations. I am glad to see here representatives of the Research Committees and Boards of the Department, who also are very often in possession of information which is confidential. That information will similarly go into the confidential section of the Bureau and be dealt with in the same way. I do not know whether that meets Mr. Beck's point. [Mr. BECK: Quite.] Then Mr. Williamson raised the question of finance. Our intention is that the service of the Bureau shall be a national service common to the whole country in so far as the country comes into touch with the Department in connection with research. It is at the service of the Research Associations as an additional service. Beyond any grant we shall make to the association there is no proposal to make any claim on the finances of the Research Association for running this Bureau. That will be a burden on the fund of the Department. [Mr. WILLIAMSON said his point was, would it be a burden on the fund of the Department, not upon the fund of the Research Association?] Yes, it will be. [Mr. WILLIAMSON said the intention of the Department being to stimulate research there did seem a possible danger that the accumulation of information would grow so that they might find the funds of the Department would be devoted more and more to that. He thought that the funds were limited to one million pounds.] Not quite, I am glad to say; but it is a very real point all the same. It is because the Advisory Council have felt so very strongly the danger of our devoting ourselves merely to the collection of the dead dry bones of knowledge that the proposals of this Bureau are so limited and so clearly defined. It is hoped in this manner, and in the way that Mr. Fleming suggested by making secondary things always secondary, to keep the scope within reasonable limits and to keep it a live organisation. As for finance, it will not be financed out of the million fund which is available for Research Associations. The Department, fortunately, has an annual vote in Parliament as well as a million fund, and we hope to be able to persuade the Treasury to allow us to carry the burden of this Bureau upon the Vote and not upon the million fund. Then Mr. Heathcote has spoken about the need for getting at original papers. On that, of course, we must never forget that it is a primary duty of a Research Association to have its own library and its own records bureau. It is not intended that the central organ shall relieve the association from collecting their own information and from having their own library. If we did we should very rapidly reach the position which Mr. Williamson fears of an enormous collection of material at the centre which was out of touch with the actual processes of industry. It is merely a crown to an edifice which must be built up, in the main, by the Research Associations themselves. At the same time anything that the Department, through the Records Bureau, can do to help Research Associations to get a sight of scarce or rare publications I can assure you they will do; and they would also, I feel sure, do everything in their power within reasonable limits, as someone else suggested, to get an extract rom a documen t that happened to be in London, and which was needed by an association which had its headquarters at a great distance. But it would never do, I think (at least I suggest for your consideration that it would not do) for the Bureau to undertake to be merely an agency for sending out extracts of papers on all and sundry subjects. The main burden must be carried by the Research Association itself, and we must come in to supplement and help and act as a kind of clearing-house and co-ordinating authority. Then the next point was that raised by Mr. Marlow, the question of interchange with America. I am not sure whether the Department would be more successful in getting rapid interchange than other organisations have been in the past. We are getting into relationship

with the National Research Council in America. We are already in active intercommunication with the Bureau of Standards, and so far as published information is concerned I think you may rely upon the Records Bureau having that information as rapidly as anybody, and we shall be very glad indeed of course to give the Research Association or other workers in connection with the Department the fullest information. The question of the rapid intercommunication of knowledge between Research Associations here and similar associations in America is, I think, a matter which we shall have to be patient about, and which will depend ultimately, as all of us must realise, upon the measure of economic competition that is likely to arise in the uture between the two countries. If we can break down the suspicion between firms in an industry in our own country we shall have gone a very long way; but rapid intercommunication of new knowledge between firms in different countries will, I imagine, take longer to establish." With regard to Mr. Reason's question the speaker suggested that possibly a personal talk would be more useful. He continued: "Then it has been suggested that I should call attention to the fact that it will be the duty of the Bureau rather to draw attention to original sources of information than to send *précis*. I think that we could do a good deal in that sort of way. We shall naturally get to know of new sources of information, and as we get the information we shall send those new sources to the associations. I fancy that that would be more useful than attempting to send *précis* of papers.

Mr. Chadwick (Woollen Research Association) said the Textile Institute comprised all the textile trades, wool, cotton, silk, jute, hemp, and flax, and it had been suggested that in those various trades the Textile Institute should form the central bureau for information. He would suggest that that idea might be taken up by others, and so save a great deal of overlapping.

Sir Herbert Jackson, F.R.S. (Scientific Instruments Research Association), pointed out that in the very early days of the war a great number of scientific people held that there should be some body set up which should be a kind of trustee of progress and activity in research work. It might be—it was not yet—that such a Department would be utterly unnecessary in twenty years more or less, because the objects to be gained by research would be so well recognised that every industry would, of course, consider research as almost its primary duty. At present he thought that the confidential information did not need to circulate but should be collected, because one of the chief things which they hoped from the Department of Scientific and Industrial Research was that it would keep a watchful eye on the whole amount of national research, and would know, because it had this confidential information, what was going on, and would be in a position to spur on others who were not doing what ought to be done, and look after the work which was being done in industry and survey the whole field. He thought that if it did that it would do a great service to the nation, and that alone would quite justify having these records without circulating them. But the principle which Sir Frank Heath had suggested of circulating information was one which was perfectly sound. When they had these pieces of information in the Department they could easily see, with the experience of a year or two, or a month or two, what it would be advisable to circulate. In the Association he had to deal with, they were faced at once with the problem of a certain thing which had been made and discovered being, they hoped, of value to another industry. How far the whole details of the research were to be communicated to the other industry was a matter for the Research Association with which he was connected. When the Department got that information it knew how to act, and in that way he did not think there need be any fear that the confidential information would be lost and wasted.

Research Workers: Conditions of Employment.

Alderman Hinchcliffe (Woollen and Worsted Research Association), in opening the discussion on this subject, said that the success of their various endeavours in the different fields of research would depend very largely on the generosity and fairmindedness with which they treated their agreements with research workers. The American Federation of Labour, he saw in a report in the *Times*, were pressing very keenly on the Government of America to push forward research in every direction in order to enable the standard of life of the community to be raised, and he took it that one of the primary objects of those present was to raise the standard of life of the community by scientific and industrial research. The Wool Textile Association, of which he was chairman, had to make agreements with professors, heads of various educational institutions in the West Riding, and investigators. The first principle he should lay down, then, was that they should pay such a salary as would put the investigator in a position where he had no family anxiety. Then they in the textile industry were out to tap all the best brains they could. With that object in view they were sending out to be put in every subscriber's factory a notice to this effect: "The British Research Association for the Woollen and Worsted Industries are desirous of encouraging discoveries or inventions in the textile trade, and are prepared to assist financially and by expert advice the promotion of any such discovery or invention. All communications will be carefully considered by the Director and the Research Control Committee, and will be treated as strictly confidential. Any further information will be supplied on application to the Secretary of the Woollen Textile Research

Association, Bond Place Chambers, Leeds." Now, if there was anything that required absolutely the most generous consideration, it was the encouragement of workmen to put their brains into the industry and to give them the results.

Sir FRANK HEATH read a letter in which the writer, the Director of the research laboratory of one of the largest engineering works in the country, urged that the payment of special amounts on account of successful work creates the worst spirit in a research staff, and suggested that general individual merit should be rewarded by salary increases, and that successful research work should be rewarded if thought desirable, by a grant to be divided amongst all members of the research staff whether they had participated in the successful research or no.

Mr. GREENWOOD (Cotton Research Association), in expressing agreement with the writer of the letter, said that they found in industry that where a man was working for a bonus as against a salary, it very often meant that he lost that real interest in his firm and in his industry that he ought to have; he was so self-centred in the idea of how his efforts would affect the reward he received.

The discussion was continued by Sir GEORGE BEILBY, Sir HERBERT JACKSON, Mr. WILLIAMSON, Colonel O'GORMAN, the Hon. Sir CHARLES PARSONS, and others.

CO-OPERATION.

The subject of co-operation amongst Research Associations for the study of accessory materials was introduced by Colonel O'GORMAN, who remarked that where the industries do not compete with one another, co-operation for the common end could more easily be initiated than where there was competition. He mentioned that there had been conducted, for an expenditure of about £1,000 (spent in one year), an astonishingly successful exploration of what in itself appeared to be a dull and unpromising territory. There was a glue shortage attendant upon the shortage of cattle; new sources of protein were sought and found, and when studied turned to good account. There was a shortage of casein for the same reason. So to treat the milk as to get more casein was difficult, but so to treat the casein as to waste less of it was found possible; accordingly an increase of useful casein by 33 per cent. was provided for by simple scientific procedure. There was a gas-tar product susceptible of utilisation as a water-excluding adhesive if certain refractory qualities could be overcome. Even these were in part overcome and they might make the remedy complete. As soon as legitimately possible these proceedings would be made public, and when they were made available no less than twelve significant industries would owe a very considerable debt of thanks to the aircraft people who, feeling the pinch very badly, moved in the matter.

Sir FRANK HEATH said it had been suggested that the best procedure would be the appointment of joint committees which might include representatives of a number of associations, and that these joint committees should have specific problems referred to them, and that by agreement between the various associations contributions from those associations should be made by which the researches could be financed. Refractories, so he understood, were a subject of very great interest to a large number of industries who used them as well as to the industry which made refractories. Now, if a Research Association for refractories, consisting in the main of manufacturers of refractory materials, came into existence, he took it that that association would not really be successful in attacking the very large number of problems which they had to attack; refractories for glass, refractories for steel, refractories for non-ferrous metals, refractories for gas, refractories for pottery—there was an enormous range of industries which used refractory materials in one way or another. If that association was going to be successful, somehow or other it had got to be in the very closest touch with the industries which used the refractories. One of the associations which was just about to come into existence was the Glass Research Association, and refractories bulked very large in their problems. It had been suggested to him that the best way of dealing with refractories for glass was to have a Joint Committee of the Glass Research Association and the Refractories Research Association working out refractories specifically from the point of view of the different industries. Refractories happened to be a subject which would force, he thought, the new association into very close relation with a whole ring of other associations. But quite apart from refractories, there must be a number of subjects similar to the one referred to by Colonel O'Gorman, glue, where two or more Research Associations were directly interested in something which, though it was not the main product of the industry, was yet of very great importance in one or other of their processes, and which appealed in that way to more than one industry. The suggestion he wanted to throw out was that they should set up these committees *ad hoc*, and then learn by experience whether that was the most successful way of proceeding. More ambitious proposals had been put forward. There were some people who thought that the fact that there was this overlapping, or this community of interests, pointed to the creation straight away of some kind of super-association which would federate the associations for these common purposes. His personal instinct—he was not speaking for the Department at all, because the Department had not made up its mind—was that that was taking rather a long step, and that the easiest and most practical way was to get committees *ad hoc*, with strict terms of reference and an allocation for the particular purpose of the committee in hand.

Alderman HINCHCLIFFE said that of course there were a number of things connected with woollen textiles, cotton, silk and flax that were common. His Association had discussed the point very carefully as to where there might be overlapping, "and," he added, "we came to the conclusion that when the other associations were properly formed it might be desirable that we should elect on to their associations, say, two or three members, and they should elect two or three on to ours. Then we should know exactly where we were meeting on common ground, and determine which association should carry on the particular research."

Mr. MARTINEAU (British Empire Sugar Research Association) thought it would be a very great advantage to have a Joint Committee of all those Research Associations which would be interested in tropical agriculture, seed-growing, seed for sugar, seed for cotton, and so on.

Sir WILLIAM MCCORMICK expressed the hope that members would send in suggestions as heads for discussions at future meetings.

Sir FRANK HEATH, in replying to a vote of thanks to Sir WILLIAM MCCORMICK and himself, said: "I think, possibly, some of you may have thought that the things we are discussing to-day, especially so far as conditions of appointments and the appointment of committees for dealing with subjects of common interest to more than one association are concerned, are things that we are going to put into practice to-morrow. We really are trying to think to-day about the day after to-morrow. It is only by discussing these things, and thinking them over and rethinking them, that it is safe to make any movement at all. Please do not imagine that we are going to act immediately; we are only thinking them over, and our minds are still perfectly open and free."

INDIAN INDUSTRIES.

II.—HIDES AND SKINS.

There are, it has been calculated, about 180 million cattle and 87 million sheep and goats in India. How large is the quantity of hides and skins available for commercial use may, to some extent, be estimated by one fact Sir Henry Ledgard mentioned in the interesting paper he read before the Society last year.* Taking the figures for 1913, he showed that the total value of India's whole exports was £162 millions sterling, of which six commodities accounted for £142 millions, hides and skins being fifth in the list. In the admirable article which forms Appendix D of the Indian Industrial Commission's Report the position and prospects of this important trade are exhaustively discussed.

* "The Indian Hide and Leather Trade," *Journal of the Royal Society of Arts*, Vol. LXVI. p. 274.

The United Kingdom has always taken the bulk of the tanned or dressed hides and a very large proportion of the tanned or dressed skins, while the raw material has gone to those countries which protected their manufacturers by the imposition of heavy duties on all but raw products. Till the war broke out, Germany, Austria, and Italy were the principal destinations to which raw hides were sent, and roughly three-fourths of the raw skins were purchased by the United States. Very little information is available regarding the internal consumption of hides and skins. Probably half the hides and nine-tenths of the skins available in the country are exported.

The export trade has, from the beginning, steadily expanded both in volume and value, and even more rapidly in value than in volume. Indian raw material fills an exceedingly important place in the leather markets of the world. Prices have constantly tended to rise, and important changes have thereby been brought about in respect of the internal consumption of leather.

A return of the exports by sea from Fort St. George for the year 1846–47 shows that 48,212 hides valued at Rs. 22,423 were exported to the United Kingdom, the average value of each hide being Re. 0–7–5, whilst in 1912–13 the sea-borne trade returns show that 13,450,913 raw hides were exported from India valued at Rs. 8,05,86,105, or an average of Rs. 6 each. Similarly, raw skins in 1846–47 were worth Re. 0–3–2 each and in 1913–14 Re. 1–9–6.

This increase in the value of the raw material has naturally affected rural economy to some extent by stimulating the improvement of the organisation for collecting hides and skins. Formerly, they were the perquisite of the village *chuckler* or *chamar*, who tanned them in a primitive way and supplied the needs of the villagers in the matter of leather. The increased value of the hides and the ease with which they can be marketed have led the *chuckler*, in many places, to abandon the tanning business and to sell the hides to dealers for cash. It has also led the villager to dispute the *chuckler's* right to the hides, and to employ him instead as an intermediary in the disposal of them; while he now purchases leather in the open market from the agents or middlemen of the organised tanneries and hands it over to a *chuckler* to make up into whatever he needs.

Indian hides differ a good deal in size according to locality and breed; speaking generally, the larger hides come from the Punjab, the

north of the United Provinces, and parts of Bombay and Madras. The inferiority of Indian hides is only partly due to the poor quality of the cattle. Branding depreciates their value enormously, and, as many of the cattle are used for draught work, their hides show signs of wear and tear. Only in the large towns, and more especially in the cantonments, are cattle killed for food, and the bulk of the hides available are those taken off animals which have died from disease, old age, or injury. Hindus are very averse from killing animals, and they allow their cattle to linger on in sickness and old age. The animals suffer and naturally their hides deteriorate, but the most fruitful source of injury is the merciless way in which cattle are branded. This is carried on to such an extreme that many thousands of hides are absolutely ruined, and large numbers of them are depreciated fifty per cent. in value through branding, which is done to satisfy the owner's æsthetic eye or calm his troubled mind. It is supposed to be efficacious in keeping away evil spirits and preventing disease, and it is also largely practised as a remedy for many diseases, especially in the nature of staggers or fits.

The prejudice against killing cattle is, however, disregarded in some parts of the country. In the Central Provinces and the United Provinces, "jerked" meat for export to Burma is prepared on a large scale, and there are a number of slaughter-houses at Agra, Damoh, Rahatgarh, Khurai, and other places, where thousands of cattle are slaughtered every day, and a trade not very dissimilar from that of the meat packers of Chicago is carried on. These establishments furnish large numbers of hides of a quality somewhat superior to those taken from the animals that die from natural causes, though the animals sent there for slaughter are usually past work.

The term "skins" is technically applied only to pelts of sheep and goats. Goat skins are larger, heavier, and of much better texture than sheep skins. Unlike hides, the majority of skins are derived from animals which have been slaughtered for food, and the pelts are, therefore, in a much better condition, and will compare favourably with similar classes of skins from other parts of the world. The tanning of skins is practically confined to Bombay and Madras, and the bulk of the business is done in the latter Presidency, the tanners of which supplement the local supplies by importing largely from other parts of India. The quality of skins varies very much with the season of the year; but, unlike hides, they are generally at their worst during the rainy season, when the animals become feverish through exposure, and the effect shows in the pelts. The hair or wool grows longer on account of the cold, and this leads to loss of tissue, with the result that the pelt is thin and papery. The majority of the dried skins are exported to be chrome tanned in America or Europe and converted into glacé kid. Skins tanned by the chrome process do not gain substance like those prepared by vegetable tanning, and plump well-nurtured skins are, therefore, in great demand by chrome tanners.

It is difficult to obtain information regarding the tanning of leather in India before the industry came under the influence of Western methods. Judging by what is now done in remote districts, where the village tanner is still uninfluenced by modern methods of procedure, it is probable that the indigenous industry was in an extremely primitive condition and that only very inferior kinds of leather were produced. Tanneries of considerable size must have existed to supply the harness and saddlery for the enormous numbers of troops and retainers who were kept under arms by the numerous rajas, zemindars, and petty chieftains, who formerly exercised more or less independent sovereign powers throughout the country. The requirements of the town population were probably small and confined chiefly to sandals and vessels for holding oil and ghee; but the ryots used large quantities of village-tanned leather for water bags, for leather thongs, and for ropes.

European methods of tanning hides were first introduced by the military authorities to manufacture superior leather suitable for harness and other military accoutrements. Contemporaneously in the early forties of last century, a French Eurasian of Pondicherry, named D'Souza, introduced improvements in the native methods of preparing skins. He is said to have visited the island of Mauritius and to have there acquired a practical knowledge of the French processes of tanning and, on his return to Pondicherry, he started a tannery and, a little later, came to Madras and set up several small tanneries in the neighbourhood of that city, the products of which were probably exported to England. Of his improvements the most important was the immersion of the tanned skins in a bath of myrabolams after the ordinary tanning had been completed. This prevents a very objectionable change in colour

which otherwise takes place on the exposure to sunlight of leather or skins tanned with *avaram* bark. There is no clear evidence that from his time till the advent of chrome tanning any further changes in the methods of tanning skins have been introduced into India. The small demand for highly finished skins in India was met by importation from Europe, and the somewhat crudely prepared Indian-dressed skins were welcomed by the tanners in Europe as the raw material from which to prepare the very best classes of light leather.

The developments of leather manufacture in contradistinction to the light tannages of Madras and Bombay are almost entirely the outcome of military efforts to obtain suitable supplies for boots and accoutrements. Where arsenals were established, tanneries usually followed.

In Europe and America machinery is very largely employed in tanneries and leather-working factories, but, although it has been employed on a considerable scale in the Cawnpore and Sion factories, elsewhere, till quite recently, it was conspicuous by its absence in the Indian tanneries, which produced the whole of the half-tanned leather and skins that bulk largely in the export trade of the country.

The action of various chemicals on hide substance has been the subject of scientific investigation for many years past, and, about 1895, the method of producing leather by means of chromium salts was thoroughly established in America on a commercial basis. The process was also taken up on the Continent and, somewhat more slowly and at a rather later date, by English tanners. Some experiments were made in India both in Cawnpore and Madras; but they resulted in nothing practical till, in 1903, the proposal was made in Madras to use leather prepared by this process for water bags for the country *mhots*. The experiments proved successful and resulted in the establishment of a Government factory, in which chrome leather was manufactured on a considerable scale and applied to a variety of purposes in place of bark-tanned leather. That this factory was prematurely closed there seems to be no doubt, as the progress of chrome tanning in India has been much slower than it is reasonable to anticipate would have been the case had Government assistance in pioneering the industry been given for a longer period. The developments have followed the line of least resistance, and, in the hands of private individuals, immediate profit has naturally been of greater importance than ultimate development. Of the chrome tanneries which were started, seven or eight have survived the initial difficulties, and are now mainly employed on the manufacture of leather for sandals and boots and shoes. The manufacture of black and brown box sides has been developed on a considerable scale, and this completely finished leather has found a profitable market in Great Britain.

At the outset it was thought that there would be a very large market for chrome leather for water bags, but progress in this direction has been comparatively slow. The rise in the price of leather has led the ryots to use light iron buckets, and competition with them left comparatively little profit to the chrome tanner. The Madras tannery was the first in the south of India to introduce the use of machinery in the tanning processes, and the success with which such machinery has been working has led to its adoption to some extent in bark tanneries. This latter development is a matter of some importance, as it has engendered a more progressive attitude amongst the Indian tanners.

Evidence of this is visible in the success which has attended the efforts of the Indian Munitions Board to stimulate the manufacture in India of certain classes of leather goods previously imported from abroad. The scrutiny of applications for priority drew attention to the possible market for locally manufactured roller skins, picker bands, leather belting, and raw hide pickers. Early in June, 1917, the Board accordingly informed Indian firms that if they could satisfy it, by production of suitable samples, that these articles could be made in India, priority applications for import from abroad would be refused. A number of the more recently established tanneries of the improved type took the matter up with most encouraging results, and, with regard to roller skins and picker bands, it is understood that they have no difficulty in disposing of their outturn. The manufacture of leather belting and of raw hide pickers proved a matter of greater difficulty, and experiments are still in progress. Excellent belting has been made from specially selected hides, but the general average is not yet up to the required standard. In regard to pickers, the large sizes used on jute looms are working satisfactorily, but the smaller pickers for cotton looms still leave much to be desired.

The highest developments of manufacture at

the outbreak of war were to be found in factories most intimately associated with the supply of material for military purposes and in the smaller tanneries devoted to the production of chrome leather. The bulk of the leather made in the country was either for internal consumption and of inferior quality or for export as half-tanned leather, to which the trade applied the term "East India Kips." Practically, the export trade was confined to Madras and Bombay, and was chiefly to Great Britain and to a much smaller extent, to the United States of America and to Japan.

Some time after the outbreak of war, the value of the "East India Kips" as upper leather for army boots was realised in England, and efforts were made to increase and regulate the supply. From August, 1916, the Indian Government, at the request of the War Office, assumed complete control of the trade, and took over from the tanners the whole of their output. The arrangements made by the Commerce and Industry Department were transferred to the Indian Munitions Board, after its creation in March, 1917. In pre-war years the exports were below 200,000 cwt., of a value of less than two crores of rupees. In the year 1917–18 they reached 360,000 cwt., of a value approaching five crores of rupees. Roughly, in four years, the output of the Indian tanneries for this class of leather only has been doubled. The control of the trade has enabled some minor, but very important, improvements to be effected, the chief of which are the prevention of adulteration and the elimination of faulty flaying.

The problem of the future is how to obtain for India a larger share in the work of preparing her abundant raw material for the market. The limits of reference preclude any discussion of the tariff question and, though the trade has been, and will continue to be, affected by whatever fiscal policy is adopted, it is assumed that if sufficiently good finished material be produced, it will be possible to sell it at profitable prices.

There is a very large, but limited, supply of Indian hides, which was not sufficient to meet the demands made upon it in pre-war times, and it may be confidently anticipated that these demands will increase owing to the diminution in the number of cattle in the belligerent countries. It seems certain, therefore, that for a long time to come there will be a very serious shortage of hides and leather. For India to obtain advantage from the situation it is necessary for her to make as good a leather from the local hides as can be made from the same hides elsewhere. The production of an inferior quality of leather will involve heavy loss, as it will only fetch a low price in competition with good leather made from similar material. There must, therefore, be no waste in this direction.

While the best Indian raw hides are distinctly inferior to the best produced under more favourable conditions in temperate climates, the Indian goat skins are of high grade and suited for first-class work. But from these skins Indian tanners have not so far been able to produce finished goods of anything like the quality that can be manufactured from them in Europe and America. In explanation of this, it has been alleged that in India it is too hot to produce first-class work, and there is no doubt whatever that the high temperature of the soaks and lime pits is a disadvantage. Tanning under tropical conditions has never been carefully studied by experts with both a scientific and practical knowledge of the trade. It may almost be accepted as axiomatic that the development of the Indian leather trade can only be accomplished by bringing to its assistance technically trained men, qualified to deal with the local problems and capable of modifying European and American methods to suit local conditions.

It is obvious that India cannot afford to neglect any of the advantages enjoyed by the tanning trade in other countries, and it may be regarded as essential that adequate provision should be made, as early as possible, for the investigation of tanning methods in India.

Hitherto the Indian trade has been run by *mistris* possessed of much practical experience, but absolutely ignorant of the most elementary knowledge of the principles underlying their practice. It is generally recognised that this can no longer continue, and that if India is to gain the position in the leather world to which she is entitled by reason of the abundance of raw material at her command, the tanning and leather industries must pass under the control of expert technologists, and scientific methods must replace empirical and rule-of-thumb working.

The inferior quality of Indian products is also due to the inferior skill and knowledge of the Indian workmen, especially in respect of the finishing of leathers. Outside the factories engaged on military work, and outside the few small ones which have sprung up as a result

of the Madras efforts to introduce chrome tanning, neither currying nor finishing leather is understood or practised, and whatever work is necessary in this direction is undertaken by the Indian *chuckler*, as a preliminary to the actual work of making the article which he has in hand. This can be remedied in the demonstration factories if skilled workmen are obtained from Europe to act as instructors.

The imports of finished leather and of goods made from leather are not unimportant, but many of them are the products of specialised factories, which it will not pay to establish in India till the demand is very much greater than it is at the present time.

The internal consumption of Indian-made leather is by no means accurately known. There are few parts of the country in which the village tanner does not still exist, and there are many small local tanneries of a slightly improved character in the south of India from which the agricultural population gets what it wants.

By far the most important item for which leather is required in India is the water bag by which water is lifted from millions of wells for the irrigation of the fields. To an appreciable extent, in recent years, iron buckets have replaced leather, and efforts are now being made to introduce cheaper fabrics made from vegetable fibres. It is not improbable that the use of leather for this purpose will steadily decrease, and, if such be the case, it will increase the visible supplies of hides on the market.

The Indian demand for boots and shoes and sandals is on the increase; but it is small as yet compared with the vast population. That it will grow in the future is a certainty, and it is likely that for boot uppers and sandals chrome leather will be very largely used. Chrome sole leather has been extensively tried and has proved extremely durable, and, in a country where pavements do not exist, the objection that it is slippery in wet weather has not the force which has practically precluded its use for footwear elsewhere.

The Indian tanning trade must, therefore, look to foreign markets for the sale of its products, and the quantity of raw material is so enormous that it will ultimately need very many large establishments to deal with it, and a high degree of specialisation seems at least possible.

There is not the smallest doubt that foreign countries will endeavour to secure the Indian raw material and to refuse Indian-manufactured leather, as in the past. Assuming, however, that they cannot get the former, they will undoubtedly accept the latter. Future developments must to a large extent depend upon the work done in the experimental factories which have been recommended; but already sufficient experience has been accumulated to show that it is possible to export from India finished leather which meets with a ready market in the United Kingdom.

The article ends by concisely stating the conclusions the Commission have reached. India produces a very large, but not definitely ascertained, number of hides and skins which are accounted for under the following heads: (1) Those wasted in rural areas by the carelessness of the local *chucklers*, or owing to the fact that the hides themselves have become valueless; (2) those made into inferior leather by the village tanners; (3) those made into a good class of finished leather by modern tanneries; (4) those half or lightly tanned and exported; (5) those exported as raw hides; (6) those exported as finished leather, and chiefly as chrome box sides. So far these exports have been insignificant in volume, but they are of great importance as indicating future possibilities.

There seems to be little doubt that after the war new tanneries will be started to produce finished leather for export, and their fate will largely depend upon the quality of the leather which they turn out. Here Government can render valuable assistance by assuming to a large extent responsibility for the technological investigations which have been indicated. Success will result in an improvement of the industry all along the line, beginning with a decrease of waste in rural areas and the diversion of the hides used by the village tanners to modern tanneries, in which a better class of leather will be produced. There will obviously be an increase in the amount of visible raw material; but whether this will be sufficient to meet the growing requirements of the country is a matter on which no definite opinion can be expressed. The general improvement of the technique in tanning will lead to an increase in the exports of finished leather and to a corresponding decrease in the exports of hides. The extent to which exports of finished leather will grow will depend upon the demand from foreign markets not closed by tariffs, and on the extent to which protected markets can be forced to accept leather made in India. Judging by the

very great value of the imports of leather into Great Britain from the Continent and from America in the years immediately preceding the war, there is obviously a very important market open to Indian tanners if they can manufacture material of sufficiently good quality. Access to the protected markets is a matter of less certainty; but there are powerful means which will doubtless be used to ensure it. The position of the manufacturer of half or lightly-tanned leathers is less assured. He should be prepared to meet the contingency of a possible decrease in the demand for his products; and this he can best face by being in a position, if necessary, to direct his energies to the production of chrome leathers.

FLAX-GROWING IN GREAT BRITAIN.

The first annual report of the Flax Production branch of the Board of Agriculture and Fisheries has been published. The branch was formed in December, 1917. The task submitted to the Board of Agriculture was to arrange for the growth of at least ten thousand acres of flax in Great Britain, to deal with the resultant crop in such a manner that seed should be available for sowing in the spring of 1919, and to manufacture the straw into fibre suitable for aeroplane cloth and other military requirements. The total area of land finally contracted for was approximately 12,352 acres. The whole of this acreage was contracted for directly by the branch for treatment in its own factories, and an additional 1,140 acres were arranged for in Yorkshire by private firms. The total quantity of seed used was 26,290 bushels. Very few growers undertook the responsibility of harvesting their crops. The operation was in most cases entirely outside their experience, and the shortage of agricultural labour had reached its climax. The branch was, therefore, faced with the necessity of fulfilling its contract to carry out the harvest operations over practically the whole area of flax grown. In the circumstances it became necessary to obtain any sort of labour that could be got. The actual cost of harvesting the 1918 crop was about £10 per acre, and to this must be added, for all areas except Fife, at least £1 for cost of camp, laying on water, preparing sanitation, etc., making £11 in all. It is when the costs of harvesting flax by ordinary local labour come to be considered that the extravagance of fixed camps of imported labour is brought to light. In Scotland practically the whole harvest was got in by unskilled local labour, paid at very high rates, at a cost of only £7 8*s*. per acre in 1919, and if the same workers could be obtained their experience would very greatly reduce this figure. These workers, moreover, were paid half wages when idle during wet weather, and many of them were entirely unused to hard work.

The exact return of the yield of the harvest cannot yet be made, as a proportion of the crop has still to be delivered. After making due allowance for short crops, on which the guaranteed minimum of £14 per acre will be paid, it is estimated that the weight of the straw and seed will be approximately 26,500 tons, distributed as follows among the various centres:—

	Total tons.	Cwts. per acre.
Fife centre . . .	2,750	41
Suffolk centre . .	3,200	37
Yeovil centre . .	6,700	39
Peterborough centre	7,550	48
Selby centre . . .	6,300	48
Total . . .	26,500	

The total cost of the guaranteed minimum payment per acre was £5,341. In the Fife centre the cost of guarantee was £547, the acreage affected being 155, the number of growers 27, and the average crop per acre 24·6 cwt.

It is obvious, with regard to future developments, that no satisfactory conclusions as to the possibility of working the enterprise as a sound commercial business can be deduced from the experience of the past year. The high prices obtainable for the products of the industry have clearly been more than discounted by the heavy cost of production. The conditions, of course, have been exceptional, and the cost of material and labour quite abnormal. That the flax industry can be made to pay in this country on a small scale has been demonstrated by the results achieved by the experimental stations established before the war.

The maintenance of the industry on the present scale, however, must depend, firstly, on the unknown future of foreign imports and prices, and the development of flax-growing in new countries.

CORRESPONDENCE.

"SPONTANEOUS COMBUSTION."

I have read the paper by Professor Watson Smith on "Spontaneous Combustion" (*Journal*, June 20th, 1919, p. 500).

May I suggest that one contributory cause in coal cargoes is the force with which coals are loaded, arising from the height at which they are dropped into the ship?

Captains have told me such combustions always start under the hatches, and have recommended that means should be contrived to break the drop and reduce the impact.

H. F. Dessen.

The above communication has been shown to Professor Watson Smith, who writes:—

Having had the privilege of a sight of Mr. H. F. Dessen's note, may I say that what the ships' captains have observed as to the force of precipitation of the coals into the ships' bunkers, I referred to in principle on p. 500, col. 2, of the

Journal for June 20th, also practically on p. 501, col. 2: "Above all things the breaking up of the ship-laden coal should be avoided . . . danger is increased through increase of surface, and in most methods of shipment the small coal and rubbish collects just under the great hatchways, and it has been proved that most outbreaks start there." What the captains recommend, then, would amount to this: break the drop and reduce the impact, and thus avoid the otherwise excessive friction. I thoroughly agree with this if the loading up can be done with the necessary speed, but I do not so much regard the *friction of impact* as I do the production of smalls, slack, and dust created by such violent loading up as the chief source of danger. Of course, under the circumstances, the smalls and dust, etc., are sure to predominate just below the hatchways, and in wet weather are certain to become the most saturated, and at the same time to offer most surface to the oxygen of the air.

WATSON SMITH.

OBITUARY.

GEORGE HENRY SYKES, M.A.—Mr. George Henry Sykes, M.A., died recently at 64, Elmbourne Road, Tooting Common. Born in Dublin in 1841, he entered Trinity College there, taking his degree of Master of Arts, and passing with honours through the engineering school attached to the University. He spent many years both in Canada and Cape Colony on constructional railway engineering work, and retired in 1885. He was elected a Life Member of the Royal Society of Arts as long ago as 1889. He was formerly a member of the Institution of Civil Engineers.

GENERAL NOTES.

THE CUNARD STEAMSHIP COMPANY AND THE WAR. —The Cunard Steamship Company have issued an interesting little booklet showing the important part which they played in the war. At the outbreak of hostilities their fleet consisted of twenty-six sea-going steamers, with a tonnage of some 330,000. Of these fifteen were lost, thirteen by direct enemy action. Losses in ships acquired subsequently brought the total up to thirty. In this way 650 seamen perished, and 60 per cent. of the pre-war fleet was sunk. Cunard liners were used as armed cruisers, transports, and hospital ships. They transported just under a million soldiers and sailors, and over ten million tons of foodstuffs and cargoes; while 100,000 tons of fuel oil for the Navy were carried in their double bottoms. Nearly 500,000 American troops were brought to Europe by Cunard vessels, being over 40 per cent. of the total carried in British ships from America. In 1915 the Company started a shell factory which turned out nearly half a million shells. Women operators were employed, and they produced the first 6-in. and 8-in. shells made by female labour. In July, 1917, the Company also constructed and managed for a time what was then the biggest aeroplane factory in England, employing thousands of hands. The booklet is illustrated with a number of photographs of remarkable interest, showing, among other things, the "Aquitania" fitted as a hospital ship, the "Mauretania" crowded with American troops, the "Carmania," fitted as an armed merchant cruiser, and the scene on her bridge after her fight with the "Cap Trafalgar" (which she sank after a duel lasting one hour and forty minutes); the "Thracia" fast in the White Sea, where she fought her way through the ice for five months, carrying a valuable cargo for Archangel, and the Cunard Aeroplane and Shell Factories.

PRODUCTION OF TILES IN SOUTH INDIA.—Inquiries were undertaken by the Department of Statistics in India regarding the output and price of Mangalore roofing tiles. Returns were received from 42 out of 70 factories. Of the remaining 28 factories, 13 were unable to reply, and 15 were either closed or amalgamated with other concerns, or only recently came into existence. The results of the inquiries, writes the United States Consul at Madras, show that the 42 factories from which returns were received turned out 61,000,000 tiles in 1916. The average selling price per 1,000 tiles previous to the war was 28 rupees (£1 17*s.* 4*d.*), and it rose during the war to 34 rupees (£2 5*s.* 4*d.*). The average selling price at Bombay was 55 rupees (£3 18*s.* 8*d.*) before the war, and this rose to 80 rupees (£5 13*s.* 4*d.*) during the war. This increase is mainly attributed to want of tonnage and a consequent rise in sea freights.

POWER SUPPLY IN INDIA.—A company has been formed in India, with a capital of forty lakhs, for the purpose of supplying electric energy to mills, factories, mines, and public buildings in Bengal and Bihar and Orissa. Important firms in Calcutta are interested in the project.

NATURAL GAS IN U.S.A.—Natural gas will be supplied to Riverside, Cal., at an early date. Pipe will be laid from a point in Los Angeles county, which means an eight-inch line of about twenty miles. A reserve tank of manufactured gas will be kept for emergencies. A new "gasser" has started on the Busmaier location, a mile north of the Arkansas River in Crawford county. At 2,315 feet the well is making 4,000,000 cubic feet of gas; 500,000 cubic feet of this coming from sand found at 1,700 feet, and the remainder from 40 feet of shale. The deep pay sand has not yet been reached. It is thought that there is a large volume of gas at a lower level, and that its pressure is so great that it is finding an outlet in the shale, in addition to the sand that is expected to be picked up in the next 50 or 100 ft.—*American Gas Engineering Journal.*

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—August 29, 1919.

No. 3485. SEPTEMBER 5, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,485. VOL. LXVII.

FRIDAY, SEPTEMBER 5, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROBLEMS OF FOOD AND OUR ECONOMIC POLICY.

By Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S.

Lecture I.—Delivered March 31st, 1919.

"L'univers est un ensemble dissymétrique . . . La vie est dominée par des actions dissymétriques."
—*Pasteur.*

In distinguishing only four elements—air, earth, fire and water—the ancients displayed great perspicacity, as these familiar expressions meet our primary needs and it is more than difficult for all but the few to resolve them into their components and activities. We must have air, earth and water for our subsistence; fire, too, is a mysterious condition which all recognise as a necessary concomitant of our vitality. Yet only the few can be aware how vast is the range of thought that must be covered if we are to comprehend the story of life, how wonderfully we are compounded of but a small number of primary materials along lines which are strangely limited in comparison with those open to the chemist in the laboratory.

Our appreciation of such problems is not markedly on the increase; consequently, complaint is often made of the public neglect of science. Indeed I was once myself a member of the chorus of complainants. Experience has made me wiser, and I must confess to the sad feeling that we are not likely to advance the multitude far along the paths of understanding. These are so infinitely diverse and intricate that familiarity with the entire scheme of the maze of Nature is all but indispensable if the way through is to be found. In our innocence, we strive to teach all and sundry and complain that they are irreceptive, if not stupid: we are only beginning to recognise that, in thus striving, we are attempting the impossible. "I have always suspected public taste to be a mongrel product, out of affectation by dogmatism," is the remark of a distinguished essayist. If for taste we substitute knowledge and for affectation ignorance, we come near to the truth. The confraternity of science cannot well be a large one. Personally, I am convinced that those who come properly within its ranks are possessed of intuitive powers of which they are themselves scarcely aware, whereby they are enabled, without exercise of special effort, to grasp meanings it is impossible to convey to the masses, whose mentality is of a different order. Whilst it is essential that every possible effort should be made to raise intelligence, our chief task must be to lead all to appreciate the value of knowledge and wise leadership; this is the crying need of our time. The situation cannot be more clearly stated than in Lowell's words:—

More men? More Man! It's there we fail:
  Weak plans grow weaker yet by lengthenin';
Wut use in addin' to the tail
  When it's the head's in need o' strengthenin'?

We are alive to the fact that the real artist—whether musician, poet, painter or sculptor—is seldom produced. This may equally be asserted of the scientific mind, which is to be ranked apart with the artistic. Science proper, however, suffers from the special disability that it cannot exert any sensuous influence: its appeal is only to the intellect, almost certainly, moreover, only to special types of intellect: so that it cannot be widely appreciated. The strange denial of science by the literary class at large cannot be explained as due to mere ignorance or lack of training; it seems rather to be the outcome of intellectual peculiarities and of narrow sympathies, the outlook of the literary mind being self-centred and mainly concerned with human affairs.

In brief, science is not mere learning but a method of progressive inquiry; it may well be defined as the art of using old knowledge ever with the object of gaining new knowledge. But the significance of the word is now so special, it covers so wide a field of thought and action, that no exact definition can well be given; the full meaning of the term comes only with understanding.

We are of the earth, earthy. But being of the earth—a member of the solar system—are but a dependant of the sun. We are built, by act of sunbeams, of tenuous air and fluent water; the solids of the earth contribute but little to our being—about 5 per cent. Our origin apparently goes back to the lowly *Bacterium*—a single-celled organism. Where that began, who shall say? That we need in no way despise such origin is clear if we reflect only on the lethal powers even the *Bacterium* commands, ever present to us in various forms of communicable disease; but if we take into account the constructive activity of the simplest forms of life we have as much reason for wonder as in considering our own activities. Apart from our intellectual powers, we can claim no supremacy, in so far as the processes of life come into account, over the simplest of living organisms; and it is mainly from these that we are learning to understand the interchanges (both constructive and destructive) which life involves.

Life in the main is a geometric process: only materials that will fit into the structure can be employed and the patterns followed are strictly limited in type. This can only be made clear with the aid of special symbols. But to use such symbols and to think in terms of such symbols is not easy.

Those who are not skilled in heraldry are aware how little they can read into a coat-of-arms, yet the expert is able to give definite meaning to every feature it presents. Although not a chemical symbol, the device recently introduced as the badge of the Chemical Corps of the American Army may be here referred to as of interest in this connection. It consists of two alembics or retorts the crossed necks of which are extended through opposite angles of a hexagon.

The alembics may be taken as the symbol of almost anything that can be distilled but, in this instance, to signify the production of nitric acid from saltpetre and vitriolic acid; the hexagon represents the hydrocarbon submitted to the action of this acid, in order to produce the high explosive of the war—T.N.T.

The alembics carry us back to the remote days of the alchemists—the days of the philosopher's stone and the elixir of life; the benzene hexagon to the Royal Institution, Albemarle Street, London, where, in 1823, benzene was discovered by Faraday. Benzene is the foundation-stone of the greater part of modern organic chemistry and of the coal-tar dye-stuff industry. If an experienced chemist were sitting at a Chinese examination and the importance of the portfolio to be gained in the administration were to depend on the completeness with which he recorded the thoughts that might crowd through the instructed mind on merely glancing at this chemical ideograph, weeks might pass before he had fully written out the story—such is the significance of a symbol!

Meredith has it that "The art of the pen is to arouse the inward vision, instead of labouring with a drop-scene brush, as if it were to the eye; because our flying minds cannot contain a protracted description. This is why the poets, who spring imagination with a word or phrase, paint lasting pictures." This, too, is the object of our chemical symbols—they enable us to paint not only lasting pictures but also character in its minute details.

For my present purpose the most important of our symbols is that of the primary vital unit—the carbon atom. Giving to this its most modern form, that of four equal spheres conjoined in a pile or pyramid, the model serves as a representation of a number of the fundamental properties recognised by the chemist as specially characteristic of the carbon atom.

A carbon atom can unite with at most four other units: it is said to have four affinities. These are typified by the four equal spheres and by the four hollows on the four faces of the pyramid into which, it may be supposed, other atoms fit when union with the carbon atom is effected. The model shows that the affinities have direction—that they act from the centre of mass of the tetrahedral figure outwards, relatively at the angle which is made by a line drawn from this centre of mass to the centre of a face.

To go a stage farther, a compound in which a carbon atom is united with four like units—say, four hydrogen atoms—may be represented by four like spheres; whilst those in which the carbon atom is united either with three like and one unlike, with two like and two unlike or with four unlike units may be represented

respectively by three black and one white; by two black, a white and a grey; or by a black, a white, a grey and a brown sphere. In this last case a geometric peculiarity of the arrangement is to be noticed. In the case of the first three it matters not how the spheres are arranged, the figure may be halved—each pyramid is said to have a plane of symmetry, a plane through which it may be cut into like halves. The fourth has no such plane and is said to be asymmetric—in whatever direction the cut be made the halves are unlike; moreover, putting the black sphere on top, those in the basal layer may be arranged in two different orders. In the one arrangement, looking down on the figure, the eye travels from black to white, thence to grey on its right and brown on its left; in the second figure, the brown and grey spheres are in the reverse order. Travelling in the direction white, grey, brown, the eye, therefore, in the one case is following a right-handed and in the other a left-handed spiral. The relationship of the two forms is similar to that between our two hands and between a pair of gloves. The two cannot be superposed any more than can our two hands or than two gloves can be worn on one hand; their relationship is also that of an object to its image in a mirror. And this is not merely a fancy picture. All such compounds are characterised by the peculiar property termed "chirality" by Lord Kelvin; in solution they turn rays of plane polarised light either to the right or to the left—if used in equal amounts, to the same extent but in opposite directions. When the two forms are present in equal amounts, the solution is optically inert, the effect produced by one form being compensated by that of the other.

This peculiarity of carbon—added to the fact that its affinity for itself is far above that of all other elements—is the most fundamental of its properties; taken together, these properties give to it its value as the skeletal foundation of the vital edifice.

The two great classes of materials of primary importance as foodstuffs are all optically active, asymmetric compounds—the starchy materials, known as "carbohydrates," as they consist of carbon combined with hydrogen and oxygen in the proportions in which these form water; and those containing nitrogen, commonly known as "albuminoids" (egg-like) or "proteins." In fact, we are built of one type of material—we may call it right-handed—and can only use this one type of material as food. We should starve on food of the optical sign opposite to that at our disposal—it would neither be digested nor assimilated. Some of our foods, such as the fats, it is true, are optically inert, symmetric material but *per se* these have only a limited constructive value in the vital edifice, serving mainly as fuel.

The first step in life is taken when carbon dioxide, CO_2, from the atmosphere, present to the extent of only about three parts by volume in 10,000, is assimilated by the vegetable cell. By means of its wonderful photochemical mechanism, in which the green colouring matter "chlorophyll" appears to be the dominant factor, the plant is enabled to capture sufficient energy from the sunbeams which fall upon its leaves to "unburn" partially both carbonic acid and water, the result being that whilst, initially, oxygen is liberated—probably from water—and carbonic acid reduced, the reduction product at once undergoes what is technicalled termed "condensation," giving rise to one or more sugars and starch. Although we cannot define the precise character of the various stages of the operation, it is certain that it is a directed process from beginning to end: that it is directed, in the first instance, by the "chlorophyll," then by other formative agents which give not only a definite composition but also a definite asymmetric structure to the products.

When sunbeams are caught by the plant, through the virid influence of chlorophyll, probably an electrolytic pulse is carried through a conducting system in which the chromatic agent is associated with both carbonic acid and water: as a consequence, atomic hydrogen is, as it were, thrown at the acid and one of the OH groups is displaced by an atom of hydrogen, giving rise to formic acid. By a repetition of the process this is then reduced to formaldehyde. All subsequent changes, whether in plant or animal, involve the loss of the energy thus secured from the sun. We are verily children of the sun.

Formaldehyde—or rather the compound which it forms with water, Formaldehydrol, $CH_2(OH)_2$—is an eminently sensitive substance. In presence of a trace of alkali it rapidly undergoes "condensation"—*i.e.*, several molecules interact and their carbon atoms become conjointed, *e.g.*—

$$CH_2(OH)_2+CH_2(OH)_2=OH_2+HO.CH_2.CH(OH)_2.$$

The condensation extends up to at least six molecules and gives rise to compounds of the Glucose type, $C_6H_{12}O_6$.

In such compounds the geometric peculiarity

above discussed necessarily comes into play, as one or more of the carbon atoms is associated with four unlike groups or radicles. The $C_6H_{12}O_6$ term, therefore, should exist in a variety of forms, identical in general composition but different because the units are differently arranged—actually sixteen are possible and, as a matter of fact, all but two have now been obtained by one means or another. How many are actually formed when formaldehydrol is "condensed" is unknown; certain it is, however, that the laboratory product is optically inert and it, therefore, follows that the optically and structurally isomeric pairs are produced simultaneously in equal amounts, as is to be expected from the doctrine of chances.

The two forms of Fructose have been isolated from the mixed laboratory product. That condensation takes place in the plant under direction—not as in the laboratory—is clear, because only one form of fructose is ever met with in Nature. Cane-sugar and Starch are the two most widely distributed carbohydrates produced in plants; the former is derived from Fructose and Dextrose, the latter from Dextrose only, we believe. In so far as the plant is built up of carbohydrate material it is largely constructed from Dextrose and Fructose (which are but alternative forms); Mannose comes next in importance; Galactose, which is very closely related to Dextrose, is widely distributed: in association with Dextrose it is the characteristic constituent of Milk Sugar. Several other members of the group occur here and there as special products. Nature, therefore, has power to do much that the chemist does but she rarely exercises it—her needs are modest: it is clear that she works with the aid of templates or moulds—*that her primary activity is a controlled and directed force at every stage.*

What is true of the carbohydrate materials is equally true of "Protein" nitrogenous materials. These are mainly derived from fundamental units of the type $CHX.NH_2.COOH$, compounds in which (unless $X=H$) four different radicles are associated with the carbon atom.

The nitrogen in these compounds, it may be pointed out, is derived primarily from the atmosphere, mainly through the aid of organisms working in the dark, either in the soil or in association with the root system of the *Leguminosæ*. The precise nature of the process is not yet disclosed but there is reason to believe that it involves the reduction of nitrogen to ammonia and the immediate conversion of this ammonia into some form of protein; it is probably an oxidative change, as it is one involving a considerable access of energy from without and the bacterial organisms productive of such changes appear to need a spare diet of carbohydrate. In principle it is similar to that involved in the reduction of carbonic acid under the influence of chlorophyll, with the difference that the energy required is derived from the correlative, oxidative change, the oxygen being made use of and not discharged from the circuit, as it is when carbonic acid is reduced.

Whereas the complex carbohydrates are all glucose-like compounds, constituted of several similar if not of like fragments, the proteins are built up of many unlike fragments; moreover, whilst the carbohydrates are neutral substances, the proteins manifest weakly both acidic and basic functions.

Digestion and Assimilation.

The process of digestion, both in plants and animals, is in large measure, in the first place, the reversal of the formative, assimilative process but carried considerably short of that from which assimilation starts in the plant; this latter is again reached, in the case of the animal, only after further changes, mainly oxidative, the reverse of the reductive changes which characterise the initial stages of assimilation in plants.

Digestion is a strictly directed process—the outcome of the activity of a special class of catalysts termed "Enzymes"—implements of surprising efficiency and extraordinary discriminative power which Nature alone wields. The manner in which they act is best illustrated by examples.

Urease.—The nitrogen in our nitrogenous foods is for the most part eliminated in the urine in the form of urea—a white crystalline neutral substance of the composition represented by the formula CON_2H_4. It is a remarkably stable substance under most conditions; by continued boiling, however, with a strong acid or alkali, it is gradually hydrolysed and resolved into ammonia and carbon dioxide—

$$CON_2H_4 + H_2O = CO_2 + 2NH_3$$

Although never met with as such in plants, it is present potentially in a number of proteins locked up in the base Arginine; it is undoubtedly a product of the retrogressive change which attends growth, especially in germinating seeds: ammonia being the form in which the plant's need of nitrogen is primarily met, there is little doubt that urea serves, as it were, as a

storehouse from which ammonia can be dealt out as required. The presence in plants of an enzyme which can induce the hydrolysis of urea is, therefore, not surprising. This enzyme—"Urease"—is strangely abundant in the soya bean. If a little ground soya bean be dusted into a solution of urea to which a few drops of an alcoholic solution of the indicator "Phenolphthalein" have been added, in a very short time the liquid turns red, a proof that ammonia has been liberated.

Invertase.—Cane sugar is not directly fermentable by the yeast organism but is first resolved, by hydrolysis, into the two simpler sugars Fructose and Glucose—

$$C_{12}H_{22}O_{11} + OH_2 = C_6H_{12}O_6 + C_6H_{12}O_6$$

which are then "fermented" into alcohol and carbon dioxide. The change may be effected by means of an acid but not by an alkali. If yeast, which has been killed by an agent such as chloroform, be ground up with a little water, a liquid is obtained which acts far more rapidly on cane sugar than does any acid. The active agent is the enzyme "Invertase." Invertase is very widely distributed in plants.

Both Urease and Invertase are easily destroyed by heat, neither surviving long when the temperature is raised above blood-heat. Both enzymes are specific in their behaviour, the one acting only on urea, not even on its derivatives, the other only on cane sugar or on compounds in which this is a component, such as Raffinose, a complex carbohydrate built up of fructose, dextrose and galactose.

Lipase.—A third enzyme, to which reference may be made, is "lipase"; this conditions the resolution of fats generally into glycerol and fatty acid, *e.g.*—

$$\underset{\text{stearin}}{C_3H_5(C_{18}H_{35}O_2)_3} + 3H_2O = C_3H_5(OH)_3 + \underset{\text{stearic acid}}{3C_{18}H_{36}O_2}.$$

Lipase is also specific in its action but has a wide range of activity; it not only hydrolyses fats—which are all glycerides of the type represented by stearin—but also ethereal salts of other "carboxylic acids."

The nature of the enzymes can only be inferred as they cannot be dealt with individually in the pure state. They seem to be colloid materials. Their singular and unrivalled activity can only be accounted for on the assumption that their structure is such that they not only fit exactly the molecules which they are able to influence—either wholly or in some particular section—but in some way serve to condition hydrolysis by bringing the elements or ions of water to bear on the particular region of the hydrolyte where scission takes place.

Theoretically, all chemical interchanges are reversible; but the conditions of reversal, to a noticeable extent, are not always those under which action takes place readily in the one direction. In the case of Lipase, as shown in the curves, whether action be started in the one direction or the other, a point of equilibrium is finally reached beyond which there is no alteration in the composition so long as the conditions remain the same. Urease and invertase apparently do not act reversibly this may be because, under laboratory conditions,

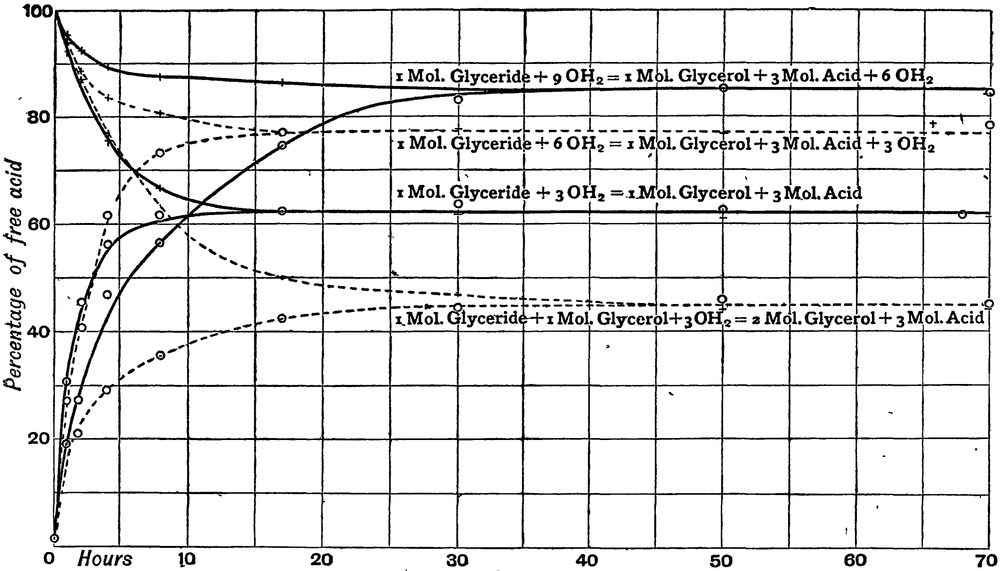


FIG. 1.

the action flashes through a series of intermediate changes which are not all sensibly repeated in the reverse direction. Under natural conditions it often happens, perhaps, that a product is conserved, either because it is at once removed from the sphere of action or because it is at once incorporated in some form of combination in which it is beyond attack; thus it is conceivable that urea may be formed, in presence of urease, only when it is at once removed from chance of attack by conversion into arginine.

The enzymes are extraordinarily sensitive agents and are operative, as a rule, only in absence of all but traces of acid or alkali. Although the end result of their action is similar to that of acids and alkalis, the manner in which they act is undoubtedly different. In the case of substances which interact in solution, action proceeds at a rate which is proportional, at any moment, to the amount of unchanged substance present in the liquid. Were it not that changes in the total molecular concentration of the solution come into play, the rate of change would be expressible by a logarithmic formula. In the case of enzymes, over a considerable range, the rate of change is independent of the concentration, the amount of the hydrolyte affected in each successive interval of time being the same, instead of being proportional to the amount in solution. But the products of change may cause an interference with the rate. The behaviour of Urease towards Urea in this respect is very remarkable, as shown by the following set of graphs.

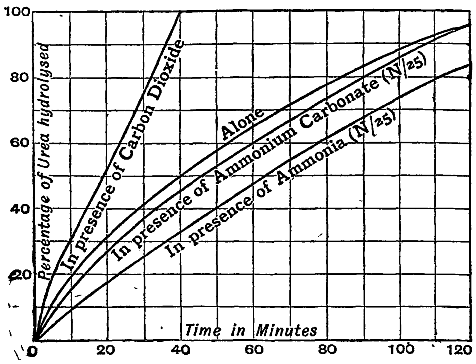


FIG. 2.

It will be noticed that when the urea is used alone, it is hydrolysed at a certain rate and that this rate is but slightly lowered by the gross product of change—ammonium carbonate. If, however, ammonia—the alkaline product of change—be added, the retardation is considerable, whence it may be inferred perhaps that the enzyme is of an acid nature. In presence of carbonic acid, however, which neutralises ammonia and is so weak an acid that any action on the enzyme is out of the question, the urea is hydrolysed at a very rapid and regular linear rate.

The peculiarities of the enzymes cannot well be explained except on the assumption that they are not soluble substances like acids and alkalis but colloids (glue-like substances) which can only be distributed as particles throughout a liquid, not dissolved in it, affording centres at which alone the action takes place.

Liquid water is to be regarded as a complex material, as a mixture of molecules of varying degrees of complexity—(OH_2), $(OH_2)_x$, $(OH_2)_y$, etc. To explain the action of enzymes, it may be assumed that a colloid surface in water is necessarily a hydronated or hydrolated surface, *i.e.*, a surface to which molecules of "Hydrone"—OH_2, the fundamental molecule of water—are attached in such manner that their activity at the surface is greater than the average activity of the water in the neighbourhood. Secondly, that as a consequence of this property of the surface the hydrolyte is attracted and absorbed from the solution, so that the colloid surface remains highly charged with the hydrolyte probably almost up to the point at which the supply in the solution is exhausted. On the assumption that the enzyme is effective within a particular region, not over its whole surface, it is only necessary that the hydrolyte should be determined to this active region. The partial or complete saturation of the surface of the colloid particles would serve, therefore, to promote the maintenance of a sufficiently constant supply of hydrolyte to this special region.*

The hydrolyte attached to the acceptor, however, would not be permanently held but would oscillate between it and the liquid, so that only a certain proportion of effective contacts would be made—contacts during which the circuit would be completed wherein hydrolysis could and did take place. The rate of change would be determined by the rate at which these effective contacts occurred but would be relatively slow, in all probability.

* E. Frankland Armstrong and H. E. Armstrong, "The Nature of Enzymes and of their Action as Hydrolytic Agents." *Proceedings of the Royal Society*, 1913, B 86, p. 561.

DIFFUSION PHENOMENA.

Apart from the constructive and destructive changes involved in the production and use of food, it is necessary to consider the diffusion phenomena and the manner in which these are connected with the occurrence of enzymic and other changes. All organisms, whether plant or animal, are cellular in their construction and the cellular envelope has special properties: only a limited class of substances can pass through it. This part of my subject is best dealt with by concrete examples. Let me refer to a very remarkable series of observations made by the late Professor Adrian Brown on the permeability of the Barley Grain.*

A variety of barley is known which is more or less blue in colour, the blueness being due, to the presence of a colouring matter which is turned red by acids; this is present as a layer close underneath the outer skin of the grain, so that if an acid pass through this outer skin and reach this layer the colour is changed to red.

By weighing barley grains, then steeping them during known periods either in water or in some solution and again weighing, Professor Brown has determined the rate of entry of water. The absorption of water takes place in a regular manner but at a diminishing rate, as shown in the diagram.

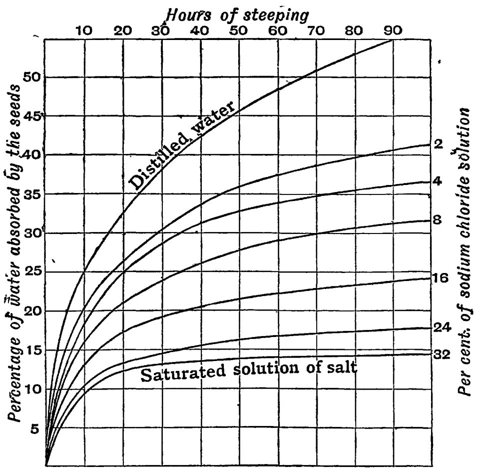


FIG. 3.

But strong acids like sulphuric, strong alkalis like caustic soda, are unable to pass through the membrane; the grains remain blue during a long period—when kept in dilute solution of sulphuric acid, for example; not only so, the solution even becomes concentrated, as water passes into the grain. Salts generally and substances such as the sugars are also unable to penetrate the membrane, although water passes in from their solutions but at slower rates than when the grain is in water alone. The property is obviously one of value in protecting the grain, not so much against entry of deleterious salts from outside when it is lying in wet ground but more particularly against the loss of the nutritive substances which are formed within it during the early stages of germination.

Such membranes are usually termed semi-permeable but the name lacks significance in some respects: as they are partitions which have a discriminating effect—they are more appropriately spoken of as differentiating or *differential septa.* Far from being permeable only by water and not by the substances spoken of, they are also readily penetrated by compounds such as the weak organic acids (acetic, butyric, etc.), the weak base ammonia, a few salts such as mercuric chloride, iodine and a large number of substances, such as alcohol and its like, ether, chloroform and even hydrocarbons such as toluene, etc. All the substances in this category are characterised by one special property: though more or less soluble in water they are but feebly attracted or held by it. When blue barley grains are steeped in a weak solution of acetic acid they soon become red; on transference to a weak solution of ammonia the colour changes back to blue.

The substances referred to affect living tissues in an entirely special manner and, as a consequence, undoubtedly play an all-important part as excitants of change. Leaves generally do not absorb water, nor when placed in water do they yield up their soluble contents; no sugar passes out into the wet soil from "roots," such as that of the beet, carrot and mangold, in which this is present in considerable amount. But if one of the substances referred to be added to the water in which sound leaves or roots are placed, the protecting membrane is in some way broken down and not only does water pass in but soluble substances pass out into the liquid. In many cases changes of a very striking character are produced when plant tissues are subjected to the influence of such substances. For example, if the mottled leaf of the common *Aucuba* (*A. japonica*) be placed either in an atmosphere of chloroform or of toluene or in water to which either of these has been added, it soon becomes black. If the water be tested, it is found to contain

* *Annals of Botany*, 1907, 21, 79.—*Proceedings of the Royal Society*, B 81, 82.

reducing sugar. The blackening is due to the interaction of an enzyme and a particular glucoside (*Aucubin*) present in the leaf, the consequence being that the glucoside is resolved into glucose and a substance which gives rise to the black colour. A more familiar case is that of the ordinary cherry laurel. It is well known that when the laurel leaf is crushed, the odours of prussic acid and of so-called bitter-almond oil are soon perceptible. Normally, no trace of these substances is exhaled from the leaves but if the leaves be placed in a bottle containing one or other of the many substances of the class under discussion, the presence of hydrogen cyanide can soon be detected, owing to an interaction setting in within the leaf cells whereby a glucoside which they contain is resolved under the influence of a contiguous enzyme into hydrogen cyanide, benzaldehyde and glucose.

In view of the stimulative effects produced by the substances considered, in conditioning chemical changes, my son and I have urged that they should be termed "Hormones," this term being one which was first applied by Baylis and Starling both to an unknown substance which is provocative of pancreatic digestion and also to carbon dioxide.*

The Hormones undoubtedly play an all-important part in the digestive and assimilative processes which accompany life. Such processes are clearly rhythmic. It is well known, in the case of the plant, that assimilation is confined to the period during which it is exposed to light; growth takes place chiefly during the hours of darkness. It is to be supposed that gateways which are more or less closed during the light period are opened during the dark period and that hormones are productive of the change. It is well known that the flowering of plants, such as lilac and the lily of the valley, may be stimulated and hastened in early spring by regulated exposure to the vapour of ether; vital changes are set in action which cause the plant to blossom prematurely. This practice is nothing short of a demonstration of my thesis that the hormones are forerunners of change.

Certain facts with regard to their action may be here emphasised. In the case of any series such as that of the alcohols, the activity increases as the solubility of the hormone in water falls off; thus ordinary alcohol, which is miscible with water in all proportions, has but slight effect in comparison with that of amylic alcohol —the chief constituent of the fusel oil separated in distilling crude fermentation spirit—which is but slightly soluble in water. As the solubility in oil increases whilst that in water diminishes, it has been supposed that the septa which are broken down are not solid but mere films of oily material. Opposed to this view, however, is the fact that the behaviour of simple aqueous solutions is precisely similar to that of the plant organism: thus the precipitation of salt from a saturated solution is influenced by the alcohols of the ethylic series to an increasing extent, as these diminish in solubility in water.

One other effect of the hormone should not be left out of account, the influence it has in hastening the rate at which water is absorbed by a system such as that afforded by the barley grain. When the rate is contrasted at which water is taken up, on steeping the grain in water alone, with that at which it enters from a solution in water of a hormone such as acetic ether (ethylic acetate), which passes in along with the water, it is found that in the presence of the hormone the rate is considerably faster.

Having thus dealt, although in barest outline, with several of the most fundamental considerations which must be taken into account, if we are to arrive at an understanding of the complex problems of nutrition, it is now possible to deal with the more pressing of these.

We dare not allow sentiment to prevail in dealing with what, after all, is the main problem of life, our bodily sustenance. And yet no phase of our existence is more subject to fashion and prejudice, more subject to interference from well-meaning idealists without the slightest qualification to judge; especially has this been the case of late years, at a time, too, when our knowledge of such matters is increasing and nearing the point at which it may be said to be scientific. In some way we must strive to rid ourselves of false sentiment and perverted idealism.

The attempt is to be made, in the U.S.A., to enforce the abolition of all vinous beverages; we are constantly urged here to take similar action. Apart from the fact that the possibility of our depriving ourselves of a freedom which has prevailed throughout the ages is questionable and the ethical justification of such interference with the liberty of the subject is in no way established, there can be no doubt that, if the grounds for a decision have not been

* *Proceedings of the Royal Society*, 1910, B 82, 588; *ibid.* 1911, 84, 226.—*Annals of Botany*, 1911, 25, 507.

altogether lacking, no proper attempt has been made to subject the problem to the complete and considered investigation that is essential. Decisions have been taken on the mere ground of opinion. A very temperate but unfortunately very incomplete discussion of the question was put forward recently in a report issued by a Committee presided over by Lord d'Abernon.

In this report only the fringe of the subject is approached, no attempt being made either to deal with the problem comprehensively in its many aspects, chemical and physical, or to take into account what is known of the action of the constituents of vinous beverages other than alcohol. Little more is done than to label ordinary or ethylic alcohol a *drug*—nothing is done to make clear the possible functions of such a substance in our dietary—at most it is admitted that it has some slight value as a fuel. The subject of vinous beverages generally—beer, cider and wine—is not considered, the implication being, apparently, that all are drinkers of ardent spirits; even of these, only those who indulge in silent spirit are considered—the peculiarities of brandy and rum are not mentioned. Other beverages than vinous are not discussed. Nevertheless, the inquiry is considered to be scientific. This is much to be regretted. Whilst we constantly complain that the public is unscientific, we fail to notice the motes in our own eyes. We cannot uphold the value of scientific opinion, if the opportunity be sacrificed, as it almost always is whenever opportunity is given to deal with problems scientifically, by our failure to make the inquiry as complete as circumstances allow; the conflict of opinion which is apparent when shortcomings and discrepancies are pointed out is necessarily misinterpreted.

I venture to claim the right to speak, as I have dealt with the subject experimentally in a variety of directions.* It has been in my thoughts throughout my life. As a chemist I could never understand how alcohol could be productive of corrosive lesions unless used altogether immoderately: it is so entirely neutral in its properties. Still more difficult was it to understand that hydrocarbons should be powerful antiseptics. Enlightenment has been acquired but slowly—it has been necessary to take into account many considerations entirely foreign, apparently, to the issues raised; only since we have secured some understanding—and that probably a vague one at best—of the problems afforded by solutions, has it been possible to draw any clear mental picture—to frame any speculation at all in harmony with the facts. And my views are probably in no way those of the multitude.

It may be supposed that Hormones generally act mainly by causing disturbances in water. And as we are largely composed of water, changes producible in water may concern us very nearly. What is water? I regard it as a mixture of units of varying molecular complexity, an interpretation now more or less widely accepted. It cannot be a mere assemblage of molecules such as are represented by the conventional formula OH_2; this is fictional water and actual dry steam. In dry steam the individual separate physical units are, for the most part at least, molecules of this simple order of complexity.

The simplest constituent of water may be termed "hydrone." Water, it may be supposed, consists of hydrone in admixture with various polyhydrones formed by the association of two or more molecules of hydrone. How many of these and what the limit of association may be, we do not know and cannot say at present. The state of water, even at steady temperatures, must be one of constant flux, of oscillatory change from form to form about a point of equilibrium. Any interfering substance introduced into the turmoil, it must be supposed, will disturb this equilibrium—presumably in the direction of an increase in the proportion of the simpler molecules; and as the simpler molecules are the more self-attractive, the liquid complex would tend, if opportunity were given, to attract such molecules to itself from outside until equilibrium were restored.

Assuming that a cell charged with water were surrounded with water—the walls of the cell being permeable by water—no change would be apparent, but it is to be supposed that there would be a constant transit of molecules across the membrane equally in both directions. The rate would be changed if a substance which could not pass into the cell were dissolved in the outer liquid—an attraction would be exercised outwards. If a substance such as alcohol were used, which could penetrate the membrane, at first the attraction outwards would also be raised; but very soon, as the alcohol passed into the cell, the rate of transit of hydrone molecules into the cell would also be raised; the result ultimately would be that

* *Journal of the Institute of Brewing*, 1913, 19, 518, "The Properties of Alcohol in Relation to its Physiological Effects."

the cell would contain more water than previously, and it would be subject to greater pressure; if originally it contained a solution, its contents would be more dilute.

The effect should be greater, from this point of view, the less compatible were the molecules of the dissolved substance with those of hydrone, as such molecules would be more effective screens. It is possible in this way to explain the much greater potency, as compared with ordinary alcohol, of the higher less soluble alcohols in Fusel Oil; the astounding efficiency of substances such as chloroform or the hydrocarbon toluene, as lethal agents, is also to be understood from this point of view.

There is one other circumstance which gives alcohol and most other hormones a peculiar potency—this is their superior solubility in fatty materials. As the brain cells and the central nervous system are charged with such materials, they offer a peculiar attraction to compounds such as alcohol and chloroform, especially to the latter; the influence of hormones of this type is, therefore, specially manifest in the regions of the brain and the central nervous system.

Alcohol and other neutral hormones probably act in two different ways—on the one hand mechanically, as it were; on the other, by inducing at least an alteration in the rate of chemical changes of normal occurrence. The nervous mechanism presumably consists of cells the deformation of which would necessarily involve some corresponding change in functional activity. Supposing that a hormone gain entry into such cells, at once a flow of water into the cells would be determined which would involve an alteration of pressure if not of form; some nervous reaction would undoubtedly supervene. But such effect would be transient, as the reverse change would set in when the supply of the interfering substance were cut off.

As the rates at which and the extent to which chemical interactions take place depend more or less on the concentration of the solutions in which they occur, alterations in concentration consequent on the entry of the hormone might well produce effects in one or other direction which might or might not be favourable.

In the case of plants, as shown by the demonstrations given earlier in the lecture, it is clear that a mechanism exists whereby the acting agents are held in restraint; this mechanism can be broken down and broken down beyond reach of repair by the entry of the hormone in sufficient amount—hence the lethal influence of the hormone. This is true equally of the highly organised plant and of the individual cell of the *Bacterium*. But in the animal, apparently, the cellular mechanism is less susceptible. This may be, in large measure because of the rapidity of the arterial circulation which renders the accumulation of the hormone difficult, particularly in a case such as that of ordinary alcohol, which is so closely allied to water and therefore takes a very low position in the toxic scale. The higher alcohols and substances such as chloroform, which are in no way avid of water, it is well known, must all be used with extreme discretion.

Conclusions such as these are entirely in accordance, it would seem, with the experience of mankind, throughout the ages. There is no evidence that vinous beverages have any harmful effect when used in moderation. The proof advanced, even by physiologists, that they induce disturbances, often borders almost on the grotesque, as if we were not affected by everything; our mental state is not the same after and before any kind of meal. Our moods are undoubtedly but the expression of chemical and mechanical changes within the brain cells, of rhythmic fluctuations of dimensions and pressures, may be the effect of autohormonic influences in many cases. If we can either neutralise or counteract such effects or quicken recovery from their influence by moderate indulgence in an agent, itself a natural product, tolerated in large amounts by the organisms which produce it, one which is in no way open to the charge of being in any special degree toxic unless used in altogether immoderate quantities, who shall say us nay? It is impossible to approve of State interference with a practice which contributes so largely to the enjoyment of life and with a liberty hitherto all but universally enjoyed by mankind, especially as interference cannot be justified by an appeal to scientific knowledge any more than it is by the reasonable interpretation of human experience.

Man is not an ascetic. "There is no duty we so much underrate," says Stevenson, "as the duty of being happy. By being happy we sow anonymous benefits upon the world, which remain unknown to ourselves or, when they are disclosed, surprise nobody so much as the benefactor. It is better to be beggared out of hand by a scapegrace nephew than daily hag-ridden by a peevish uncle."

FRENCH TOY INDUSTRY.

Paris is the chief centre of the French toy industry, and considerable progress has been made by the Paris manufacturers towards expanding this trade.

One of the largest toy concerns in France is the Société Française des Bebes Jumeaux, capitalised at over £170,000. It is estimated that there are four hundred and fifty manufacturers of toys in France, only a few of whom have a capital exceeding £50,000, and five or six £4,000. The concerns of average importance number perhaps forty or fifty; the others are of minor importance, conducted mostly by workmen without capital, skill, or commercial experience.

In 1915–16 the son of the late President Carnot started a factory near Paris for toys made by wounded soldiers, and from a small beginning the enterprise has grown until it now employs two hundred or three hundred people.

The Lepine Toy Fair is held yearly in Paris to encourage the manufacturers to make new and different toys, and much is done also in this direction at the annual Lyons Fair. Efforts are being made by the large department stores, and stores specialising in toys, to encourage the toy trade. Considerable space is devoted exclusively to the exhibition of toys of French manufacture. Advertising is done extensively in the newspapers, as also by means of elaborate posters. The Christmas window displays are exceedingly attractive. The prices demanded are, however, unusually high for all toys.

It is feared that when more normal conditions prevail, foreign, and especially German, competition will seriously handicap the French doll trade. In Germany the largest factories are in remote districts, where the work is done by the peasants, whereas in France the factories are situated in or near the large cities, where the cost of living is much higher. Before the war nearly all the dolls' heads and enamelled eyes used were purchased by the French manufacturers from Germany. Since 1914 these essential parts of dolls have been made in France at Limoges, Boulogne-sur-Mer, and in the suburbs of Paris.

A business was organised in Paris last year with a capital of £160,000, which is attempting to make dolls' heads, besides dressing the dolls. This firm is receiving large orders, and its dolls are meeting with considerable success.

Most of the mechanical toys now sold in France are made by small manufacturers, and, to a less extent, by individuals. The sales of toy soldiers, guns, ships, etc., have been satisfactory. With the exception of a few toys such as steam engines and electrical toys, France depended upon Germany before the war for mechanical toys. Dominoes and dice have been manufactured at and near Méria, but the business has been curtailed on account of the scarcity of bone.

It appears from a report by the United States Consul-General at Paris that, until its recent revival, the French toy industry had been on the decline for some years. No figures of the total value of the French production of toys are obtainable, but the estimates are between £400,000 and £480,000 per annum. The toy industry in France is regarded as a luxury industry, so that the manufacturers have been obliged to create new toys and to adopt special methods for bringing them before the public. To this end the Comptoirs d'Echantillons (sample counters or sales departments) were created, of which there were a number in Paris before the war. The most important was the Sample House, which contained several thousand samples of toys of all kinds. Buyers for the large retail stores went there to select the toys, and the commission merchants brought their clients there, in this way avoiding the necessity of stocking up and carrying toys over from season to season.

The success of the German toy trade in France is said to be due to

1. Cheapness of the German toys.
2. The greater number of models, the choice and purchase being facilitated by the sample stores at Paris; the Leipzig Fair, and the keenness of the German salesmen; quick delivery and manner of packing.
3. The easy terms of payment granted on purchases by German manufacturers.

Some apprehension is apparently felt in France with regard to competition from toys from Japan as soon as transportation is improved.

In summing up the French toy industry, it may be said that the industry is small and extremely limited except for high-class toys suitable for a certain class of trade. This is mainly due, says the United States Consul-General, to the want of experience, lack of capital willing to enter into this industry, and the cheapness at which toys have been and will be offered by foreign competitors.

SWATOW PINEAPPLE CLOTH AND OTHER TEXTILES.

Although the manufacture of cloth from pineapple fibre is a minor industry of the Swatow district, a brief description of it by the United States Consul at Swatow may be of some interest. In the Fengshun district there are pineapple plantations specially cultivated for the fibre. The Kityang district also produces fibre, the annual estimated production of both districts being valued at £4,800. The figures of the Maritime Customs show a considerable import from native ports (chiefly Hainan Island, according to dealers). In 1913 this import was 549,867 lb.; in 1914, 457,200 lb.; and in 1917, 240,933 lb. The trade also states that a small supply of inferior grade fibre comes from Formosa, its average annual value being about £4,800.

The extraction of the fibre from the leaf is a simple process. The green leaf is first soaked in a solution of lime-water, and then taken out and scraped with a piece of broken chinaware or glass, the scraping motion being away from the operator

and toward the pointed end of the leaf. The fibres are next pulled out by using the thumb nail and forefinger, and, after being soaked in water and washed, are sun-bleached. A hundredweight of leaves will give about a pound of fibre. One workman, with a minor assistant or two, can prepare $1\frac{1}{3}$ lb. of fibre per day.

For weaving into cloth the fibre must be made into thread, the process being as follows: The worker, invariably a woman, selects sufficient fibre for one day's work and soaks it in fresh water for about half an hour. The fibre is split into threads of the desired size at the thick end and pulled apart. Two threads are then joined by doubling the small end over the thick end of another thread and rolling on the knee. The only twisting is where the threads are joined. This process is repeated until the desired length is obtained, the thread being run into a basket and later sun-dried. The loose thread is then wound into a ball. When run on to bobbins and spools it is ready for weaving. Jute and ramie threads are made in the same way.

The native loom is used entirely in weaving this cloth. The ordinary width of the cloth is between 15 and 16 in., and the maximum width between 18 and 20 in., which is called "special" width. The length of the cloth varies between 80 to 100 ft., and various grades are made. Sometimes, to add to the appearance of the cloth, ramie thread is used for the woof. This cloth is widely used for summer clothing.

Jute Cloth Production.—Jute is grown throughout the Swatow district. Local production, in addition to supplying the local demand, furnishes a considerable quantity for export. This product goes principally to Sumatra for making gunnybags. In Swatow it is used in making cordage, sacks or bags, and mourning cloth.

The jute plant grows to an average height of 7 ft., and is harvested in August. When full grown but still green, it is pulled out of the ground and the skin removed. The skin is taken off in one piece by breaking the stem near the top, removing the short piece of stem and pulling off the skin from the remainder. The exterior of the skin is then scraped by means of a heavy, dull knife, after which it is dried in the sun. In this form it is exported as jute skin or made into cordage. For weaving purposes it is separated into threads, as described for pineapple fibre.

Jute cloth (sackcloth), for mourning wear, is made on the native loom in widths between 15 and 16 in., and in lengths varying between 90 and 110 ft.

Ramie Fibre.—Ramie fibre is by far the most important product of those included in this report. Ramie is grown to a very small extent near Kityang, the great source of supply for the local industry being Hankow. The fibre is made into thread or twine by the process above described for pineapple fibre, and either exported in that state or woven into grass cloth for home consumption and export. The chief manufacturing centre in the district is Kityang. A reliable estimate of the total production is not obtainable. The exports through Swatow of products made from ramie are as follows:—

	Grass Cloth.		Ramie Thread and Twine.		Drawn Work.
	Quantity.	Value.	Quantity.	Value.	
	lb.	U.S. Dollars.	lb.	U.S. Dollars.	U.S. Dollars.
1914	753,867	441,415	1,408,667	192,477	..
1916	777,467	1,395,450	1,120,667	216,656	34,460
1917	805,868	870,172	1,067,200	247,418	36,730

With the exception of 215,200 lb. in 1916 and 244,000 lb. in 1917, the grass cloth exports went to other parts of China. Ramie thread and twine are exported to Hong Kong and the South Seas chiefly, and drawn work principally to Hong Kong.

Grass cloth is made in many grades, which are usually classified as either coarse or fine. The coarse grades, in pieces 15 in. wide by 80 ft. long, sold wholesale at the end of last year at between 10*s.* and 15*s.* per bolt, and the fine grades 16 in. by 90 ft. at between 16*s.* 8*d.* and 26*s.* 8d. per bolt. This cloth is also woven in the "special" widths 18 to 20 in. The native loom is used exclusively. Much of the Kityang grass cloth on the market is dyed either a navy blue or sky blue colour.

Drawn-work Industry.—In the drawn work fine Kityang grass cloth, and still finer imported Canton grass cloth (from Hsin Tui), are used. The latter also recommends itself on account of being woven on foreign looms in 32-in. widths. This industry has been much affected by the war, but it is now hoped that it will soon revive.

PRODUCTION OF CHILI PEPPERS IN MEXICO.

The growing of chili peppers in Mexico is confined chiefly to the States of Vera Cruz, Aguascalientes, San Luis Potosi, and Lower California, and the district around San Martin, in the State of Puebla. The latter district is in normal times one of the most important for the cultivation of this product for export. The soil and climate are particularly well adapted, and it has been the principal local product so long that the farmers have become experts in its

production; but it is thought that until normal conditions are more nearly restored in the district cultivation will be practically nil.

According to a report by the United States Vice-Consul at Mexico City, the territory adjacent to Tampico, from which that city draws its supplies, is probably the first in importance for the present cultivation and production of the various species of chili peppers. Tampico is itself a large centre for the consumption of peppers. Of the Ancho pepper alone (a wide, dried red pepper), approximately 22,000 lb. are shipped every month to Tampico from the States of Vera Cruz, San Luis Potosi, and Aguascalientes. This particular pepper is sold in the Tampico market at about 2*s*. per lb.

The "Pico de Pájaro" pepper is smaller than the Ancho, and is produced in and shipped from the same States to the Tampico market. The monthly quantity of this grade of pepper is about 880 lb., and it sells at about 2*s*. 3*d*. per lb.

The chili chiltepen, also a small red pepper, is produced near Tuxpam, in the State of Vera Cruz, about 75 miles south of Tampico. The importation into Tampico of this variety of pepper averages 6,600 lb. per month, and it sells at about 5*s*. per lb.

The green chili includes both the large and small peppers, and is grown in the Huasteca district of Vera Cruz State in large quantities, with the greatest acreage along the Tamesi River. This variety is taken into the Tampico market in amounts averaging 66,100 lb. per month, and is sold at about 1*s*. 6*d*. per lb.

Several favourite brands are found on the Tampico market. The sweet, large-sized pepper, in 1 lb. tins, under the trade name "Especialidad Pimientas Morroncillos," manufactured in Spain and selling at 4*s*. 2*d*. per tin, is probably the most popular. Second in demand is the 1 lb. tin of hot pepper manufactured locally and selling at 3*s*. 1*d*. per tin. Another popular brand is that known as the "Chili Piquines," put up in 6 oz. bottles and manufactured in Mexico City.

The chili peppers are so largely in demand for local consumption in all the markets as to entirely exclude exportation.

The principal section of production in the State of Vera Cruz is along the Interoceanic Railway from Vera Cruz to the Isthmus. In normal times the crops are large and profitable, and quantities of the product are shipped to Mexico City, Toluca, and other marketing and canning points.

Another productive region for the growth of chili peppers is the extreme southern end of Lower California, particularly between the towns of La Paz and San Jose del Cabo. The principal districts are the sandy stretches of land near Eureka and the vicinity around the towns of Mulegé, San Ignacio, San Agueda, and San Bruno, comprising the trade territory of Santa Rosalia. Cultivation here, however, is waning somewhat since the growing of cotton and sugar-cane is proving more profitable to the farmers.

In the State of Jabisco there is also an important production of three varieties of peppers. The first in order of quantity produced is the "chili colorado," with a production of approximately 30 tons per annum. The "chilacate" comes next with a production of 20 tons annually, the third variety being "chili pasilla," of which there is a yearly production of 18 tons.

GENERAL NOTES.

National Physical Laboratory.—The Lord President of the Council has appointed Dr. Joseph Ernest Petavel, F.R.S., Professor of Engineering and Director of the Whitworth Laboratory in the University of Manchester, to be Director of the National Physical Laboratory in succession to Sir Richard Glazebrook, C.B., F.R.S., who retires on reaching the age limit on September 18th next. The Albert Medal of the Royal Society of Arts was awarded in 1918 by the Council, with the approval of the President, H.R.H. the Duke of Connaught, to Sir Richard Glazebrook "for his services in the application of science to the industries of peace and war, by his work as Director of the National Physical Laboratory since 1899, and as Chairman of the Advisory Committee for Aeronautics." In 1913 Dr. Petavel delivered before the Society a course of three Howard Lectures on "Aeronautics."

Shipping and Shipbuilding.—Owing to the expansion of shipbuilding in America the tonnage launched in 1918 was nearly two-thirds greater than in 1913. Even this expansion, the *Monthly Bulletin of Statistics* shows, was not sufficient to offset the low output of mercantile tonnage during the war, apart from the losses due to submarines and mines. At the middle of 1919, eight million gross tons were under construction, an increase of one million tons on the corresponding figure for the end of 1918. Half of the increase was contributed by British shipyards. While the records of shipping entered and cleared in 1919 exhibit in general a recovery from the level of those during the war, there is in all the countries, Japan excepted, a more or less substantial reduction from the volume of movement previous to the war. Notwithstanding the considerable concentration of shipping on the North Atlantic route the monthly entrances and clearances at U.S.A. ports were, at the latest dates for which particulars are available, still nearly one-fifth lower than in the year before the war.

Proposed Tunnel in Japan.—It has been decided to cut a submarine tunnel under the Shimonoseki Strait. At present the railway systems in Honshu and Kyushu are connected by ferry-boats. The scheme provides for the completion of the work in 1928. Two years will be spent in studying the geological formation of the sea-bed, and in drafting the general plans. Actual work will be commenced in 1921. The total length

of the line will be seven miles, of which one mile will be completely under the sea. When completed, a through service between Tokyo and Kagoshima will be possible.—*Railway and Locomotive Engineering.*

Life of Electric Vehicles.—In January, 1919, there were 3,288 electric vehicles in the New York Metropolitan District, this number being 10 per cent. of the total number of self-propelled vehicles in use. Statistics show that the average life of electric vehicles is thus well over ten years, whereas that of other types of motor vehicles is about five years. During the first ten years' life of an electric vehicle it can be kept in operation 280 days out of a possible 300 in the year, which is ten days more than the service obtainable by other types of vehicles.—*Electrical Review* (Chicago).

THE LIBRARY.

The following books have been presented to the Library since the last announcement. Except where otherwise stated they have been presented by the publishers:—

Bright, Charles, F.R.S.E., M.Inst.C.E.—Telegraphy, Aeronautics, and War. London: Constable & Co., Ltd., 1918.

Butler, Nicholas Murray.—A World in Ferment. New York: Charles Scribner's Sons, 1918.

Cain, John Cannell, D.Sc.—The Manufacture of Intermediate Products for Dyes. London: Macmillan & Co., Ltd., 1918.

Cannan, Edward, M.A., LL.D.—Money: its Connexion with Rising and Falling Prices. London: P. S. King & Sons, Ltd., 1918.

Cantell, M. T.—Reinforced Concrete Construction. Part I. Second Edition. London: E. & F. N. Spon, Ltd., 1918.

Crotch, Arthur.—The Elements of Telephony. London: E. & F. N. Spon, Ltd., 1918.

Dall, W. H., D.Sc.—Spencer Fullerton Baird. Philadelphia: J. P. Lippincott Co., 1915. Presented by the Smithsonian Institution.

"Demos."—The Meaning of Reconstruction. London: George Allen & Unwin, Ltd., 1918.

Devillers, René.—Automobile and Aero Engines. Translated from the French by Captain W. J. Walker, B.Sc. London: E. & F. N. Spon, Ltd., 1919.

Dickson, Archibald A. C.—The Mica Miner's and Prospector's Guide. London: E. & F. N. Spon, Ltd., 1919.

Dye, Frederick.—Hot-Water Supply. Sixth Edition. London: E. & F. N. Spon, Ltd., 1919.

Etchells, E. Fiander.—Mnemonic Notation for Engineering Formulæ. London: E. & F. N. Spon, Ltd., 1918.

Greene, J. Arthur.—A Treatise on British Mineral Oil. London: Charles Griffin & Co., Ltd., 1919.

Grillo, Ernesto, D.Litt., LL.D.—A New Italian Grammar. London: Blackie & Son, Ltd., 1918.

Hale, A. J., B.Sc., F.I.C.—The Applications of Electrolysis in Chemical Industry. London: Longmans, Green & Co., 1918.

Hayward, F. H., D.Litt., M.A., and Arnold Freeman, M.A.—The Spiritual Foundations of Reconstruction. London: P. S. King & Son, Ltd., 1919.

Hobhouse, Professor L. T., D.Litt.—The Metaphysical Theory of the State. London: George Allen & Unwin, Ltd., 1918.

Johnson, Douglas Wilson.—Shore Processes and Shoreline Development. London: Chapman & Hall, Ltd., 1919.

Lehfeldt, R. A., D.Sc.—Gold, Prices, and the Witwatersrand. London: P. S. King & Son, Ltd., 1919.

Mackenzie, Professor J. S., Litt.D., LL.D.—Outlines of Social Philosophy. London: George Allen & Unwin, Ltd., 1918.

Mordin, R.—The Strowger Automatic Telephone Exchange. London: E. & F. N. Spon, Ltd., 1919.

Pack, Charles Lathrop.—The War Garden Victorious. Philadelphia: J. P. Lippincott Co., 1919.

Pattison, J. T., F.C.S.—The Manufacture of Aluminium. London: E. & F. N. Spon, Ltd., 1918.

Railway Officer.—Railway Reorganisation. London: E. & F. N. Spon, Ltd., 1919.

Rawlley, Ratan C., M.A., M.Sc.—The Silk Industry and Trade. London: P. S. King & Son, Ltd., 1919.

Robertson, T. Brailsford, Ph.D., D.Sc.—The Physical Chemistry of the Proteins. London: Longmans, Green & Co., 1918.

Schoeller, W. R., Ph.D., and A. R. Powell.—The Analysis of Minerals and Ores of the Rarer Elements. London: Charles Griffin & Co., Ltd., 1919.

Secerov, Slavko, Ph.D., M.Sc.—Economic Phenomena before and after War. London: George Routledge & Sons, Ltd., 1919.

Silberstein, Ludwik, Ph.D.—Simplified Method of Tracing Rays through any Optical System. London: Longmans, Green & Co., 1918.

Stokes, Dr. Alfred C.—Aquatic Microscopy for Beginners. Fourth Edition. London: Chapman & Hall, Ltd., 1918.

Webster, A. D.—Firewoods: their Production and Fuel Values. London: T. Fisher Unwin, Ltd., 1919.

Year-Book of Wireless Telegraphy, 1919. London: The Wireless Press, Ltd., 1919.

Young, Clyde, F.R.I.B.A.—Spon's Practical Builder's Pocket-Book. London: E. & F. N. Spon, Ltd., 1918.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—September 5, 1919.

No. 3486. SEPTEMBER 12, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,486. **VOL. LXVII.**

FRIDAY, SEPTEMBER 12, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

EXAMINATIONS.

The results of all stages of the examinations held from May 26th to June 4th have now been sent to the centres concerned.

In the Advanced Stage 2,538 papers were worked. Of these 368 were awarded first-class certificates, 1,274 second-class certificates, and 896 failed.

In the Intermediate Stage the number of papers worked was 8,540, with 1,217 first-class, 4,286 second-class, and 56 certificates in Harmony and Rudiments of Music; the failures numbered 2,981.

In the Elementary Stage 9,168 papers were worked. The passes numbered 6,021, and the failures 3,147.

In 1920 the first, or Easter, examination will commence on Monday, March 22nd, and finish on Wednesday, March 31st. The second, or Whitsuntide, examination will commence on Monday, May 10th, and finish on Wednesday, May 19th. The syllabus for 1920 will be published in a few days.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROBLEMS OF FOOD AND OUR ECONOMIC POLICY.

By Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S.

Lecture II.—Delivered April 7th, 1919.

"A man should be ashamed to take his food if he has not alchemy enough in his stomach to turn some of it into intense and enjoyable occupation." —*Stevenson.*

"An apple a day keeps the doctor away."—*Old saw.*

At the outset of his Cantor Lectures on Foodstuffs, delivered four years ago, Professor Somerville made the statement:—

"Upon many workers in the field of practical medicine the conviction has of late been forced that largely, if not wholly, in proportion as we understand aright what happens to foods as they enter the body, are incorporated with the cells of the organism and as so much waste material finally leave it, so can we hope to be able to assist the body in disease; and that in this matter all other considerations are of but minor importance."

To understand aright what foods are, what foods are necessary and to follow the changes they undergo, must be a task of enormous difficulty and magnitude, one, too, that must be regarded from many points of view if we are to arrive at an ultimate solution of the innumerable problems the subject presents. No discussion can be of greater public importance—nothing less than the well-being of our race is the stake in the game we play with food materials; but it is only too clear that there are many foolish players in the game—that it is one for which rules have yet to be written that will reduce it to an ordered and sane exercise.

I have urged already that, in some way, we must strive to rid ourselves of false sentiment and a perverted idealism, which often is nothing short of fanaticism, in dealing with what, after all, is the main problem of life—our daily sustenance. I have referred to the attempt to enforce the abolition of all vinous beverages as one example of such interference.

Another is upon us from a quarter that, to say the least, makes its appearance a danger of no mean order. Rudyard Kipling, in one of his "Just So Stories," pictures woman as having tamed man when she first discovered to him the virtues of the grilled marrowbone. Meredith puts the case more blankly through one of his characters in "Richard Feverel," Mrs. Berry, who, in giving a cookery book as a wedding present, remarks to the recipient:—

"When the parlour fire gets low, put coals on the kitchen fire! And a good saying it is to treasure. Such is man! No use in havin'

their hearts if ye don't have their stomachs." Perceiving that she grew abstruse, Mrs. Berry added briskly: 'You know nothing about that, yet, my dear. Only mind me and mark me: Don't neglect your cookery. Kissing don't last; cookery do!"

The new woman, presumably, will eschew kissing: will she take up cookery? In seeking to do all that man does, if not to displace him, most unfortunately she is tending to abrogate and render up her domestic functions; far too few among the leaders of the movement are alive to the dangers such action must involve. That we must all work is certain; it is equally clear that we cannot all do the same work—some division of labour there must be; any attempt to depart from the course of evolution will inevitably fail. The more we can co-operate and all perform the functions most suited to their natures—and we differ to an extraordinary degree—the happier we shall all be.

Women happily are more and more devoting themselves to scientific studies. Unfortunately, the arbiters of their fate, the examiners—unmindful of the world and its needs—insist on posing purely academic and professional standards; the vulgar subject of food scarcely counts—a bare wisp only of the food-cloud is all that is to be seen on the educational horizon, at present. This disability has to be removed. The women must take their fate more into their own hands. The women's colleges, thus far, have been too much man-managed; at least the experiment should be tried of allowing women—real women, not pseudo-men—to take charge. I would turn out the men entirely from colleges such as Holloway College and King's College for Women at Kensington. Let them, if they will, appeal occasionally for advice and ideas to men, real men, domestic men but not to the purely academic neuter who goes by the name of man. Force them, if possible, to work out woman's domestic salvation by themselves. The need is great, if the whole nation is not to be plunged into worse than discomfort.

A real living interest in foodstuffs has to be created. The theme is not merely one of the most vitally important but the most vitally important that we have to consider: to those who can grasp the problems it is poetry pure and simple, the poetry of form and motion. The difficulty is to reduce the unavoidable complexities to terms of a doctrine which will serve to interest and guide the public.

Great and most necessary advance has been made in our appreciation of the fundamental problems of nutrition, even during the war, largely owing to the efficient aid given by women workers; valid methods of inquiry are now established and it is beyond question that results of the greatest public importance will be obtained if it be permitted to us to extend and develop such inquiries systematically. It is already clear that the low state of physical development of the masses is largely due to faulty feeding and that the real means of improving the general level of health will be found in the dissemination of proper knowledge and of some understanding of the problems of nutrition among the public. Thus far such problems have not received the needed attention even at the hands of the medical profession; until medical education be given a scientific foundation there will necessarily be little advance. Such foundation should be truly laid without delay.

But serious if not fatal interference with progress, with progress which would be wholly and solely in the public interest, more especially that of the poorer and less informed class of the community, is now imminent in the threatened passage of the "Dogs Protection Bill"—but a stage in the movement on the part of "sentiment" to interfere with inquiries carried on with the sole object of safeguarding human life by arriving at an understanding of its processes. Sir Edward Schafer, the experienced physiologist, in a letter to *The Times* of April 5th, speaks of the measure as likely to arrest completely the progress of physiology in this country. The effect must be far more fatal if, in the end, the use of animals for the purposes of inquiry into vital processes be interdicted; such action would, in large measure, render inoperative the work of the new Ministry of Health, by depriving the medical profession of the opportunity of arriving at a proper understanding of human functions.

During the war, owing to the many opportunities afforded of making experiments upon man himself, the practice of surgery has been much improved; and it is generally known that the art of the surgeon has been greatly developed in recent times since Lister made it possible for him to operate with safety and he was placed in a position to try experiments and test these by results. Medicine has made no corresponding advance, largely because of the impossibility of making experiments corres-

ponding to those of the surgeon and the uncertainty attending the interpretation of the results of those that are made—owing to the number of factors that are operative in the case of the human subject and our inveterate tendency, whenever possible, to meet and oppose any novel treatment which may be put upon us. I am told that the majority of the Committee who considered the Bill would not and could not consider expert argument—nor is it likely to be otherwise: without the sympathy begotten of understanding there can be no appreciation of argument. This is our danger under democratic control; it is the function of Government to save us from this danger. Sir Edward Schafer is right in appealing to the Government to take into account the experience gained in the war and to protect the nation against the unbridled operation of uninformed sentiment. "Science" cannot but speak with one voice in support of such action. Also, as *The Times* points out, it is for the educated classes to do their duty.

One of the gravest faults in our system of education and of public practice has been that we have never acquired the saving grace of modesty; few fail to assume—especially if men of affairs, or of business, so-called—that they have the right to an opinion on any and every subject, however complete may be their ignorance thereof, although none of us will admit the right of another of different occupation to interfere in his business. It has been well said that "the tenacity of many ordinary people in ordinary pursuits is a sort of standing challenge to everybody else."

ENZYMES.

Thus far, in considering the changes food materials undergo, reference has been made only to two types of agent—to enzymes and to hormones.

The enzymes have been pictured as specific agents of an altogether peculiar character, strictly selective in their action: that is to say, as substances capable of inducing change only in compatible substances to which, it is necessary to believe, they bear some definite structural relationship. Usually they act as hydrolytic agents or the reverse; a question to be considered will be whether they may or may not take on other functions at times. Whatever the limitations may be which affect their action, there can be no doubt that the essential function of the enzyme is to determine the formation of a molecular circuit or system within which electrolysis can take place. They therefore belong to the great class of *Catalysts;* they are organised catalysts, in fact—the catalyst being defined as the agent which brings about the inclusion of inter-acting substances in an electrolytic circuit within which change takes place so soon as the circuit is established, the electrolyte being the actual agent by which the change is effected.

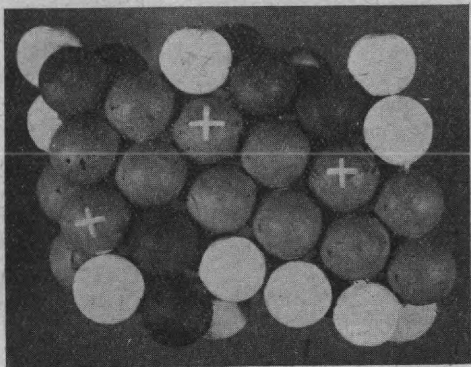


FIG. 4.—FRONT.

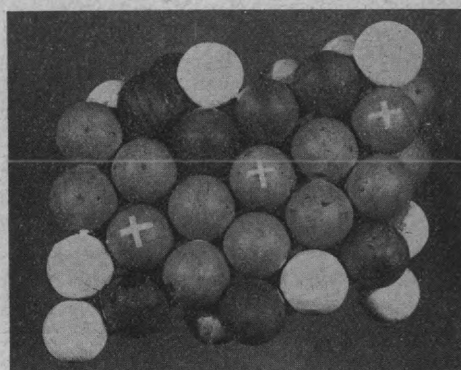


FIG. 5.—BACK.

Hydrolysis or its reverse is necessarily an operation in which the two ions of water condition the two opposite operations of hydrogenation and hydroxylation in correlative proportions and in contiguity.

The manner in which an enzyme may be supposed to exercise a directive influence can be illustrated with the aid of the close-packed assemblage shown in Figs. 4 and 5, representing a front and a back view of a single unit in the crystalline complex of glucose.

In this model, which I owe to Mr. Wm. Barlow, F.R.S., the pyramids representing the six carbon atoms are arranged in contiguity and are to be regarded as united at opposing

faces; the pyramids are therefore placed alternately base downwards and base upwards, so that three sets of three spheres, each set belonging to a carbon pyramid the fourth sphere of which is in the back plane, are to be seen at the front and back faces of the model; on the other hand, each of the three spheres marked with a cross is at the apex of a pyramid of which the remaining three spheres are located in the back plane. The white balls represent hydrogen atoms. The dark balls, in pairs, represent oxygen atoms. An attractive force may be postulated as exerted at the surface of each of the triplets in a face.

Elsewhere, in discussing the nature of enzyme action, I have assumed that an enzyme contains an element which is compatible with the compound which it is able to hydrolyse and that this is in close contiguity with an acid or basic radicle which can condition hydrolysis.

Assuming that an acid radicle were in close association with the assemblage shown, an electrolytic circuit might well be established comprising the enzyme and compatible molecules—such as those of formaldehydrol—which had been attracted to its surface: as these molecules became attached, in consequence of the disturbance of the affinities in the complex affected by juxtaposition with the new molecules, an electrolytic thrill would pass through the entire system and this might condition the interaction of the groups which had been appropriately seated on the directing surface of the enzymic system: the groups would in consequence be joined up in a definite order. It is possible, in this way, to account for the exclusive formation of a substance such as dextroglucose.

Fermentation.

The greater part of our food serves but one purpose—that of fuel; sugars, fats, proteins are ultimately resolved by oxidation into the carbon dioxide and water from which they came, the nitrogen alone being returned at a slightly higher energy level, mainly as urea. In large measure, in the earlier stages at least, the changes are conditioned in some mysterious way by water—but by the correlative action of its two ions, as in fermentation.

One of the greatest surprises of recent years has been the discovery that alcoholic fermentation can be carried on apart from the living cell—with the aid of materials merely expressed from yeast. The changes passed through are now in some measure revealed, though the nature of the process is in no way made clear as yet. Apparently, at an early stage, the glucose is simply converted into pyruvic acid —$CH_3.CO.COOH$, which is then resolved into aldehyde, $CH_3.COH$, and carbon dioxide, the aldehyde finally undergoing reduction to alcohol, $CH_3.CH_2.OH$. Obviously, at first, the change is one involving oxidation; but, in the later stage, the change is in the opposite direction—reductive; maybe, when the action is once started—the yeast organism is known to require oxygen at the outset—the two opposite operations are compensatory. In some fermentations, as in the production of butyric acid from lactic, hydrogen is actually evolved, together with much carbon dioxide. The production of fats from carbohydrates is evidently an analogous process.

Oxidation.

It is not improbable that in the course of the oxidation process, changes such as those involved in fermentation may either be followed by directly oxidative changes or that such changes may be correlative with and supplementary to changes that are characteristic of fermentation.

Oxidation is effected through the agency of the oxygen carried forward in the blood stream in loose combination with hæmoglobin: there is every reason to believe that this oxygen functions simply as a depolarizer and is initially converted into hydrogen peroxide, which, however, is not an oxidising agent *per se*; it needs a catalyst to render it active.

Ferrous iron and, in a lesser degree, manganese salts, are well known oxidative catalysts. If hydrogen peroxide be introduced, for example, into a solution of potassium iodide containing starch, there is no immediate effect; on adding only a trace of ferrous sulphate the liquid at once becomes blue, showing that iodine has been liberated. In like manner, nothing happens when tartaric acid and hydrogen peroxide are brought together; the addition of a little ferrous sulphate, however, at once determines the oxidation of the acid.

It is not difficult to explain these effects. Like water, hydrogen peroxide is not an electrolyte but an electrolyte is produced by the interaction of ferrous sulphate and the peroxide—

$$\left.\begin{matrix}HSO_4\\HO\end{matrix}\right\}Fe + HO.OH = \left.\begin{matrix}HSO_4\\(HO.O)\end{matrix}\right\}Fe + OH_2.$$

This "perhydrol" can then function as

the depolarizer, together with the oxidisable substance, in an electrolytic circuit, *e.g.*—

$$Fe\begin{cases} SO_4H \\ O.OH \end{cases} + xH \ldots OH + 2KI =$$

$$Fe\begin{cases} SO_4H \\ OH \end{cases} + H_2O + x - 1H \ldots OH + 2KOH + I_2.$$

If the perhydrol be not so placed that it can effect oxidation but is in presence of an excess of hydrogen peroxide, this latter is destroyed and oxygen evolved. This is the well-known *catalase* effect, which plays so important a part in the plant, leading to the evolution of oxygen in sunlight.*

Assuming that the enzymes are active, in many cases, through the agency of an acid radicle (CO.OH), it is conceivable that they might be convertible into perhydrols (COO.OH) and thereby function as hydroxylating (oxidising) catalysts, at least at the early stage, when the compatibility of the agent with the substance attacked is a matter of importance.

Such oxidising enzymoid catalysts might also indirectly condition reduction—if a sufficiently easily oxidisable substance were included in the circuit.

Unfortunately it is impossible to test such speculations in the laboratory, as enzymes cannot be isolated and worked with individually. But that the oxidation of glucose in the body is a directed process may be regarded as established by the fact that, in diabetes, it more or less entirely escapes destruction, passing out in the urine, whilst fats and proteins are dealt with and degraded in the ordinary way.

A similar argument may be applied to the apparent failure of the organism to oxidise homogentisic acid in cases of alkaptonuria.†

Dakin and others have dwelt on the fact that hydrogen peroxide is the one agent by which oxidation products may be obtained in the laboratory in agreement with those noticed in the animal system, other oxidising agents, as a rule, acting differently. Whilst this is a strong argument in favour of the view here put forward, it is in no way surprising, as most oxidising agents destroy hydrogen peroxide. The hypothesis is also justified by the behaviour of the fatty acids on oxidation, whether in the body or by hydrogen peroxide in presence of a ferrous salt: ultimately the acid is converted into the lower homologue in which the number of carbon atoms is *two* below that in the oxidised acid, a result which involves the conclusion that initially the attack always takes place at the third carbon atom, as in the case of butyric acid, for example, which before it is converted into acetic acid affords the following products—

$CH_3.CH_2.CH_2.COOH$ butyric acid — $CH_3.CH(OH).CH_2.COOH$ hydroxybutyric acid

$CH_3.CO.CH_2.COOH$ acetoacetic acid

This result has been thought to be surprising but on reference to the figure given above, representing glucose, it will be seen that in the model depicted the attracting surfaces of carbon atoms 1 and 3, not those of 1 and 2, are in immediate contiguity though they are not combined. In an acid perhydrol, the excess of oxygen would be in juxtaposition with hydrogen attached to the third carbon atom rather than with that attached to the second; it might be expected therefore that interaction would take place in this region if an electrolyte were appropriately interposed.

If an enzymic mechanism such as that now pictured be at any stage concerned in the oxidative degradation of glucose, diabetes might be the consequence of its more or less complete destruction. But it is also conceivable that, just as the ferrous perhydrol mechanism is thrown out of action by an oxidising agent such as permanganate, so in diabetes some interfering process comes into play and negatives the action of the enzymic mechanism. In this latter case, the chance of discovering some ameliorating agent is greater and the outlook more hopeful.

Anaphylaxis.

Finally, it may be mentioned that we have not the slightest clue, at present, to the manner in which the formation of enzymes takes place. The changes involved in the production of anti-toxines and vaccines are even more mysterious; we are entirely without knowledge of the nature of the protective process. The organism is clearly on guard but the response when strange substances are introduced—the elimination of benzoic acid as hippuric acid and the formation of various glycuronates, for example —is the only indication at hand from which we can infer what may be its character.

Hitherto this all important subject has been dealt with far too exclusively from the point of view of the bacteriologist and pathologist: the superabundant Greek terminology, in which it is enwrapped, may be soothing to the ear but it leaves the mind a blank on all essential points.

* "Studies on Oxidation. The nature of the process in which hydrogen peroxide is utilised. Iron salts as catalysts." C. S. Mummery, *Journal of the Society of Chemical Industry*, September 30th, 1913.

† Garrod, "Inborn Errors of Metabolism." Oxford University Press, 1909.

Unfortunately the field is one in which there has been no real attempt hitherto to bring chemistry to bear—rather has the chemist been kept at a distance; but the prospect is now brightening and it may be anticipated that inspiration will be derived from the further study of the strange phenomena of "Anaphylaxis." No surprise could be greater than the discovery, in recent years, that by the introduction, in minute amount, of so neutral a material as a protein into its blood stream an animal is rendered sensitive, after a certain interval, to the particular protein but not to others, the introduction of a further amount of the protein into the circulation having a lethal effect. The change produced appears to be of an extended character, as it is found that, if the uterus of a sensitised guinea-pig be dissected out and placed in water, on stirring into the water a little of the protein used in sensitising the animal, the uterus at once reacts by rising up, showing that the whole muscular surface has been affected.

Finally opportunity may be taken to point out that just as the bricklayer advances the mortar as he lays his bricks, so must it be supposed is the enzymic mechanism advanced as it fulfils its constructive purpose. The recent demonstration by Ball of a large number of growth-rings bordering on the ultra-microscopic in the individual cotton hair, each marking a day's growth, is most suggestive in this connection, as is also the very definite structure of starch granules. The constant production of enzymes in the digestive tract must involve changes of the order contemplated: in fact, the enzymic mechanism may well be destroyed as it advances and leave little if any proof of its presence in its rear—just as the amidated materials in the coniferous tree especially are constantly called on to deliver up their nitrogen, so that it may be re-used in advance of growth: the terpenes, the oxidised oils and resins, so commonly met with in plants, being probably the exuviæ of this conservative process.

Functional Adjuvants.

Apart from the production of the enzymic mechanism, it is necessary to consider also its liberation for use in cases where it does not act *in situ*. The best studied case and the most suggestive, although inexplicable at the moment, is that studied by Bayliss and Starling. According to these observers, the enzyme in pancreatic juice is liberated from the intestinal mucous membrane when this is subjected to the action of very weak chlorhydric acid—but by a secondary process, through the liberation of a substance which they have termed *Secretin*. This substance appears to be the same in all animals, not specific to different kinds. It withstands such rough treatment that it cannot be an enzyme; and probably it is a substance of low molecular weight.

It was in connection with the discovery of this substance that Bayliss and Starling coined the term *Hormone*. But I would venture to plead that this term should be applied rather to the large class of chemically neutral substances, including nitrous oxide, alcohol and its congeners, the ethers, chloroform, etc., which act primarily as mechanical disturbing agents and in virtue of their irresistible penetrative power, not selectively and functionally. I would rather term secretin and similar substances *Functional Adjuvants*.

The number of such substances now recognised, derived from various glands, is considerable. Thus the Pituitary gland, at the base of the brain, supplies a substance which seems to be of importance in regulating growth—or at least in determining stature.

Another is afforded by the thyroid gland in the neck, the removal or disease of which involves much general disturbance of the normal course of life. When it is diseased in children, the species of idiocy known as Cretinism is produced; in adults "the whole body becomes unwieldy and clumsy, like the mind." An entirely successful treatment of the disease, if kept up for life, involves grafting the thyroid of another animal into the abdomen; the injection of thyroid extract subcutaneously; or even feeding on the thyroid of other animals. The active substance is known as iodothyrin.

One of the most remarkable of the functional adjuvants is adrenalin or adrenin, the characteristic secretion of the suprarenal glands associated with the kidneys. The function of adrenalin appears to be that of controlling the arterial system. When administered subcutaneously, it enormously accelerates and augments the force of the beat of the heart, causing a great rise in blood pressure, the outflow of blood from the veins almost ceasing. This effect rapidly subsides. Adrenalin acts on the nerves of the sympathetic system, it is believed only on the nerve endings; and is itself derived from "sympathetic" material. In this case we have to do with a substance of simple structure, nearly related to phenylalanine and tyrosine, both constituents of most proteins,

How are we to picture the regulative influence of such significant substances as exercised? The methods of electro-magnetic control are familiar to most; it is well known that they are make-and-break methods. Being subject to control from a head centre, in response to messages interchanged with the various regions of the body, the vital mechanism may well be pictured as governed by a succession of orders which are passed on or not according as the lines of communication are open or closed. The function of a substance such as adrenalin may well be that of bridging an interval and of closing up a gap, so establishing a circuit. Being a soluble material, the maintenance of the circuit would depend on the constant supply of the substance at some definite rate—otherwise it would be washed away and the circuit would be broken. The proportion of adjuvant supplied, on this assumption, would determine the number of times contacts were established and circuits made: the function it controlled would therefore rise and fall accordingly.

On this view, the functional adjuvants are not neutral substances but are productive of specific chemical effects. It may be, however, that in some cases a single substance may behave as a "neutral" hormone—that is to say, be capable of penetrating cellular membranes generally—and also as an adjuvant or chemically active agent.

Food Accessories or Advitants.

In close connection with these functional adjuvants must be reckoned the accessory substances shown by modern inquiry to be of such vital importance as food materials. Unfortunately these have been prematurely christened "Vitamines"—a name to which, very properly, objection is taken, not merely because it is based on an erroneous interpretation of results but as too definite an indication of character. At present we are entirely ignorant of their nature. As they are necessary to life, I propose to speak of them as *Advitants* a name which is significant, without being an indication that they belong to any special type. Probably they are of different types: perhaps all three of the types of agent thus far considered may be counted among them.

In former days those who went down to the sea in ships were fed on the worst of diet and suffered accordingly, especially from scurvy. Readers of Captain Cook's voyages will have had their attention called to the measures which he took to avoid this disease. The following summary of these, given by Capt. Wharton in his edition of the voyages, is of particular interest.

"Precautions against the terrible scourge, scurvy, had not been forgotten.

"Besides the supply of all anti-scorbutics then known, a special letter was written to Cook directing him to take a quantity of malt to sea, for the purpose of being made into wort, as a cure for scorbutic disorders, as recommended by Dr. McBride.

"The directions for its use were as follows:—

"The malt must be ground under the direction of the surgeon and made into wort, fresh every day, in the following manner:—

"1. Take one quart of ground malt and pour on it three quarts of boiling water. Stir them well and let the mixture stand close covered up for three or four hours, after which strain off the liquor.

"2. The wort, so prepared, is then to be boiled into a panada with sea biscuit or dried fruits generally carried to sea.

"3. The patient must make at least two meals a day of the said panada and should drink a quart or more of the fresh infusion, as it may agree with him, every twenty-four hours.

"4. The surgeon is to keep an exact account of its effects.

"Though it is somewhat anticipating events, it is convenient to record here the result of these efforts to defeat the hitherto unconquerable enemy. Mr. Perry's report at the termination of the voyage is as follows:—

"Sour krout, mustard, vinegar, wheat, inspissated orange and lemon juices, saloup, portable soup, sugar, molasses, vegetables (at times when they could be got), were, some in constant, others in occasional use. These were of such infinite service to the people in preserving them from a scorbutic taint, that the use of the malt was (with respect to necessity) almost entirely precluded.

"Again, cold bathing was encouraged and enforced by example; the allowance of salt beef and pork was abridged from nearly the beginning of the voyage and the sailor's usual custom of mixing the salt beef fat with their flour, etc., was strictly forbad.

"Upon our leaving England, also, a stop was put to our issuing butter and cheese and throughout the voyage raisins were served with the flour instead of pickled suet. At Tierre del

Fuego we collected wild celery and every morning our breakfast was made with this herb with ground wheat and portable soup.

"We passed Cape Horn, all our men as free from scurvy as on our sailing from Plymouth.

"Three slight cases of scorbutic disorders occurred before arriving at Otaheite. Wort was given, with apparently good effect and the symptoms disappeared.

"No other cases occurred during the voyage but the wort was served out at sea as a regular article of diet.

"To this it may be added that no opportunity was, as appears by the Journal, ever lost of getting wild celery and any other wild herb that presented itself.

"The personal washing is mentioned by Mr. Perry and the tradition in the Navy is that the men's deck was more constantly scrubbed than had then been usual; in fact that unusual attention was paid to cleanliness. Stoves were used to dry the decks below even in hot weather."

Mindful of his success in combating scurvy and making use of his experience, in his second voyage Cook carried with him all his former antiscorbutics and redoubled his general precautions as to cleanliness both of person and ship. The result was completely immunity from more than symptoms of scurvy.

Scurvy has always followed famine but nevertheless it was not regarded as a deficiency disease—nor could it well be so long as we had little or no knowledge of the nature of foodstuffs and of the processes of nutrition. The idea prevailed—it was that more or less favoured by "authority" in the early period of the late war—that so long as there was sufficient untainted food to fill the belly and provide the necessary fuel to keep the body warm, all might be well.

The tendency was to regard antiscorbutics as correctives to some condition set up by the food: in later days, when ptomaines and toxins were brought on the stage, it was thought that these might be causative of the effects observed; then, when bacteria became fashionable and their malign influence filled our thoughts, they in turn were accused of being the evil-doers. The proof that scurvy is a deficiency disease is entirely the outcome of experiments made with animals under such conditions that there can be no other interpretation of the results.

In point of fact, Dr. (now Sir) Thomas Barlow is to be regarded as in many ways the chief pioneer thinker in the field under consideration. As far back as 1883 he discussed the peculiarities of no less than thirty-one cases of what he believed to be infantile scurvy, since known as Barlow's disease. In his Bradshaw Lecture, delivered in 1894, on "Infantile Scurvy and its relation to Rickets" (*British Medical Journal*, November 10th, 1894), in which many more cases were considered, he speaks of "prolonged deprivation of fresh vegetables or their equivalent as the most constant fact amongst the antecedents of the disease—prolonged, because it is clear that the organism has the power of drawing on its reserves for lengthened periods to meet the deprivation of a complete aliment; the phrase fresh vegetables or their equivalents being used because we now know that fresh uncooked meat and fresh milk are antiscorbutic as well as, though perhaps not in so rapid a way, as fresh vegetables and fresh fruit juices. . . . It seems fair to say that the further we get from a living food the less is the antiscorbutic power. Fresh vegetables are more powerful antiscorbutics than preserved or cooked vegetables. Raw meat is more antiscorbutic than cooked meat and raw meat juice than beef tea. I suspect," added Dr. Barlow, "it will ultimately be found that raw, uncooked milk is more antiscorbutic than cooked milk."

None of the children considered in 1883 had been breast-fed; they had been given what may be called "preserved foods." "In the front rank came the various proprietary infant foods, prepared by the addition of water to certain powders. Then come the different forms of condensed milk and the proprietary foods made with condensed milk. Then come cases in which, either accompanied by proprietary food or not, fresh milk has been given but extremely diluted, during the last stages of infancy. The reasonableness of these explanations was proved by the startling recovery, after two or three days, when undiluted cows' milk was substituted for diluted—a full pint for a child six months old; by mixing some sieved potato, instead of the proprietary food, and a tablespoonful of meat juice or gravy, with the milk every day, and finally administering in divided doses, mixed with water, a tablespoonful of orange juice or fruit juice."

Speaking in 1894, Dr. Barlow said that here the disease was more frequent than twenty-five years previously and that it was increasing in frequency in America. The reason of this

probably was the growing difficulty of getting mothers to suckle their infants and the enormous increase in England and America in the use of proprietary infant foods. These foods were much more extensively used among the well-to-do than by the poor. But different forms of condensed milk had also come into extensive use, particularly among the poor. Though by no means exempt, the children of the poor were to a remarkable degree less affected by the disease than were those of the rich. The children of the poor received small portions of the food of which their parents partook at a much earlier period than those of the well-to-do: potatoes especially were given at a much earlier period. Consequently, although rickety, the children of the poor were less frequently scorbutic.

Although the practical significance of Barlow's observations was clear and they were of the greatest value in influencing medical opinion, they had little effect in guiding scientific inquiry—the time was not yet come when they could be appreciated. The next great step forward was taken by Eijkman in Java through the investigation of *beri-beri*, a nervous disease by which the rice-feeding populations of the East were greatly afflicted—but it is remarkable, in reading the account of these inquiries, how gradually other explanations were put aside and this disease was only ultimately shown to be due to a deficiency of dietetic factors, not imposed from without. Eijkman's observations are considered later on.

Real enlightenment first came when Gowland Hopkins, in 1912, published his account of an exhaustive inquiry carried out with rats, under the title, "Feeding Experiments Illustrating the Importance of Accessory Factors in Normal Dietaries."

The immediate outcome of this inquiry was the recognition of an indispensable growth factor in our diet, present only in small proportions. Groups of young rats were fed upon artificial mixtures of isolated casein, fat, carbohydrate and salts. Side by side, similar groups were fed on the same basal dietary but with the addition of a small ration of fresh milk—amounting at most to 4 per cent. of the food eaten. The rats without milk soon ceased to grow; but growth was normal and continued in the case of those receiving milk.

Indispensable Structural Materials.

It is only since the proteins have been studied exhaustively and it has been shown that they vary greatly in composition (both as to the nature of their constituent units and the relative proportions in which these are present), that the value of a mixed diet and the importance of varying our food has been understood. Milks are the only whole foods at man's disposal which can be used alone with safety over long periods—but they are of animal origin and the natural food of the young mammal; probably cow's milk does not entirely suffice us at all periods of life. No immature vegetables seem to be a complete food and even fruits are incomplete mammalian foods. "Man lives not by bread alone" is not merely the statement of a fact but also the denial of a possibility only recently appreciated by science; our modern bread taken alone is simply a murderous diet and, even when made from whole meal, it must be properly supplemented. When fed on oats and bran only, guinea pigs rapidly become scorbutic. But milk and oatmeal constitute a highly nutritious diet. It was formerly the custom, I am told, in Scotland to supply the agricultural labourer with a certain amount of oatmeal as well as such milk as he required: he often lived solely on these. At each meal he would put as much oatmeal as he thought fit into a bowl and, after adding salt, would pour boiling water on the meal and mix them so as to form a stiff paste, then he would add the milk and proceed to eat the mixture, which was known as Brose.

Much work has been done, especially by Osborne and Mendel in the United States of America, to ascertain whether life can be maintained with the aid of a single selected protein instead of mixtures of several such as are contained in ordinary dietaries. It is now established that this is possible, provided that the material used contain all the nitrogenous compounds recognised as structural units of the various proteins.

Another type of inquiry has involved a close watch being kept whether or no nitrogenous equilibrium could be maintained with the aid of this or that material. Experiments of this order have shown, for example, that this is not possible when the material used is gelatin, a protein which affords as chief cleavage product a very large proportion of glycine (amino-acetic acid), which is but a very minor constituent of most proteins. Gelatin is also destitute of both tyrosine and tryptophane; better results are obtained when it is used together with tyrosine. Although gelatin is an insufficient nitrogenous food alone, it is of value as

an economiser of protein and in this respect is even superior to fats and sugar.

The most conclusive series of observations showing the value of a particular structural unit are those of Gowland Hopkins, first published in full in 1917, although the main conclusions of the inquiry were established half a dozen years earlier. The compound proved to be indispensable was tryptophane, a substantial constituent of caseinogen from cow's milk; it may be detected in most proteins by a highly sensitive colour test. But in all inquiries of the kind referred to, although it was often possible to maintain full-grown animals alive over considerable periods, sooner or later they died unless a change to normal diet were instituted; and no matter what the protein used, in the case of some of the animals, the artificial dietary never sufficed to maintain the growth process. The experiments made by Hopkins involved feeding one set of mice on a diet containing the isolated protein of maize, zein—which is destitute of tryptophane—together with starch, sugar, fat, lecithin and salts; another set being fed on a similar diet to which a small percentage of isolated tryptophane had been added. Although the mice suffered a daily loss of weight from the outset and all succumbed in the end, those fed on zein alone were torpid and had an average life of only sixteen days, whilst those receiving tryptophane were active and alert and had an average life of thirty days. In the light of later observations, it is probable that necessary advitants were missing and that had these been present the results when tryptophane was supplied would have been far more if not entirely satisfactory.

BRITISH ASSOCIATION.

Presidential Address.

After an interval of three years the annual meetings of the British Association for the Advancement of Science were resumed at Bournemouth on September 9th under the presidency of the Hon. Sir Charles A. Parsons, K.C.B., F.R.S.

In his address on the occasion, the President said they were gathered together at a time when, after a great upheaval, the elemental conditions of organisation of the world were still in flux, and they had to consider how to influence and mould the recrystallisation of these elements into the best forms and most economic rearrangements for the benefit of civilisation. That the British Association was capable of exerting great influence in guiding the nation towards advancement in the Sciences and Arts in the most general way there could be no question. After remarking that it was 29 years since an engineer, Sir Frederick Bramwell, occupied that chair, the President referred to the Centenary of James Watt and the achievements of that celebrated Scotsman. England had gained her present proud position by her early enterprise and by the success of the Watt steam engine, which enabled her to become the first country to develop her resources in coal, and led to the establishment of her great manufactures and her immense mercantile marine.

The next subject the President entered upon was turbines. The turbine of to-day, he said, carries the expansion of steam much further than has been found possible in any reciprocating engine, and owing to this property it has surpassed it in the economy of coal, and it realises to the fullest extent Watt's ideal of the expansion of steam from the boiler to the lowest vapour pressure obtainable in the condenser.

Among the minor improvements which in recent years have conduced to a higher efficiency in turbines are the more accurate curvature of the blades to avoid eddy losses in the steam, the raising of the peripheral velocities of the blades to nearly the velocity of the steam impinging upon them, and details of construction to reduce leakages to a minimum. In turbines of 20,000 to 30,000 horse-power, 82 per cent. of the available energy in the steam is now obtainable as brake horse-power; and with a boiler efficiency of 85 per cent. the thermo-dynamic efficiency from the fuel to the electrical output of the alternator has reached 23 per cent., and shortly may reach 28 per cent., a result rivalling the efficiency of internal-combustion engines worked by producer gas.

During the twenty years immediately preceding the war, turbo generators had increased in size from 500 kilowatts to 25,000 kilowatts, and the consumption of steam had fallen from 17 lb. per kw. hour to 10·3 lb. per kw. hour. Turbines have become the recognised means of generating electricity from steam on a large scale, although they have not superseded the Watt engine for pumping mines or the drawing of coal, except in so far as it is a means for generating electricity for these purposes. In the same period the engine power in the mercantile marine had risen from 3,900 of the "King Edward" to 75,000 of the "Mauretania."

As regards the Royal Navy, the engine power of battleships, prior to the war, had increased from 12,000 i.h.p. to 30,000 s.h.p., while the speed advanced from 17 knots to 23 knots, and during the war, in ships of the "Queen Elizabeth" class, the power amounted to 75,000 s.h.p., with a speed of 25 knots. In cruisers similar advances were made. The i.h.p. of the "Powerful" was 25,000, while the s.h.p. of the "Queen Mary" was 78,000, with a speed of 28 knots. During the war the power obtained

with geared turbines in the "Courageous" class was 100,000 s.h.p., with a speed of 32 knots, the maximum power transmitted through one gear wheel being 25,000 h.p., and through one pinion 15,500 h.p., while in destroyers, speeds up to 39 knots have been obtained. The aggregate horse-power of war and mercantile turbined vessels throughout the world is now about 35 millions.

These advances in power and speed have been made possible mainly by the successive increase in economy and diminution of weight derived from the replacement of reciprocating engines by turbines direct coupled to the propellers, and, later, by the introduction of reduction gearing between the turbines and the propellers; also by the adoption of water-tube boilers and of oil fuel. With these advances the names of Lord Fisher, Sir William White, and Sir Henry Oram will always be associated.

With the great work of the Royal Navy fresh in their minds, they could not but recall the prominent part taken by the late Sir William White in its construction. His sudden death, when President-elect for 1913, lost to the nation and to the Association the services of a great naval architect who possessed remarkable powers of prevision and dialectic. He was Chief Constructor to the Admiralty from 1885 to 1901, and largely to him was due the efficiency of our vessels in the great war.

White often referred to the work of Brunel as the designer of the "Great Eastern," and spoke of him as the originator of the cellular construction of the bottoms of ships, since universally adopted, as a means of strengthening the hull and for obtaining additional safety in case of damage. Scott Russell was the builder of this great pioneer vessel, the forerunner of the Atlantic liners, and the British Association might rightly feel satisfaction in having aided him when a young man by pecuniary grants to develop his researches into the design and construction of ships and the wave-line form of hull which he originated, a form of special importance in paddle-wheel vessels. The President proceeded:—

So much discussion has taken place in the last four years as to the best construction of ship to resist torpedo attacks that it is interesting to recall briefly at the present time what was said by White in his Cantor Lectures to the Royal Society of Arts in 1906: "Great attention has been bestowed upon means of defence against underwater torpedo attacks. From the first introduction of torpedoes it was recognised that extreme watertight subdivision in the interior of warships would be the most important means of defence. Experiments have been made with triple watertight skins forming double cellular sides, the compartments nearest the outer bottom being filled, in some cases, with water, coal, cellulose, or other materials. Armour plating has been used both on the outer bottom and on inner skins." He also alludes to several Russian ships which were torpedoed by the Japanese, and he concludes by saying: "Up to date the balance of opinion has favoured minute watertight subdivisions and comparatively thin watertight compartments, rather than the use of internal armour, whose use, of course, involves large expenditure of weight and cost."

The present war has most amply confirmed his views and conclusions, then so lucidly and concisely expressed.

While on the subject of steamships, it may perhaps be opportune to say one word as to their further development. The size of ships had been steadily increasing up to the time of the war, resulting in a reduction of power required to propel them per ton of displacement. On the other hand, thanks to their greater size and more economical machinery, speeds have been increased when the traffic has justified the greater cost. The limiting factor to further increase in size is the depth of water in the harbours. With this restriction removed there is no obstacle to building ships up to 1,000 ft. in length or more, provided the volume and character of the traffic are such as to justify the capital outlay.

Among other pre-war developments that have had a bearing upon the war the President mentioned the discovery and extensive use of alloys of steel and the investigation of gaseous explosions, with special reference to temperature. Coming to the next section of his address, "Science and the War," the President was reminded that in the course of his Presidential Address to Section G, in 1858, Lord Rosse said: "Another object of the Mechanical Section of the Association has been effected—the importance of engineering science in the service of the State has been brought more prominently forward. There seems, however, something still wanting. Science may yet do more for the Navy and Army if more called upon."

Comparatively recently, too, Lord French remarked: "We have failed during the past to read accurately the lessons as regards the fighting of the future which modern science and invention should have taught us."

The President continued: In view of the eminent services which scientists have rendered during the war, I think that we may be justified in regarding the requirement stated by Lord Rosse as having at last been satisfied, and also in believing that such a criticism that Lord French rightly uttered will not be levelled against the country in the future.

Though British men of science had not formerly been adequately recognised in relation to war and the safety of their country, yet at the call of the sailors and the soldiers they whole-heartedly, and with intense zeal, devoted themselves to repair the negligence of the past, and to apply their unrivalled powers and skill to encounter and overcome the long-standing machinations of the enemy. They worked in close collaboration with men of science of the Allied nations, and eventually produced better war material, chemicals, and apparatus of

all kinds for vanquishing the enemy and the saving of our own men than had been devised by the enemy during many years of preparation planned on the basis of a total disregard of treaties and the conventions of war.

Four years is too short a time for much scientific invention to blossom to useful maturity, even under the forced exigencies of war and Government control. It must be remembered that in the past the great majority of new discoveries and inventions of merit have taken many years—sometimes generations—to bring them into general use. It must also be mentioned that in some instances discoveries and inventions are attributable to the general advance in Science and the Arts which has brought within the region of practical politics an attack on some particular problem. So the work of the scientists during the war has perforce been directed more to the application of known principles, trade knowledge, and properties of matter to the waging of war, than to the making of new and laborious discoveries; though, in effecting such applications, inventions of a high order have been achieved, some of which promise to be of great usefulness in time of peace.

The advance of Science and the Arts in the last century had, however, wrought a great change in the implements of war. The steam engine, the internal-combustion engine, electricity, and the advances in metallurgy and chemistry had led to the building up of immense industries which, when diverted from their normal uses, have produced unprecedented quantities of war material for the purposes of the enormous armies, and also for the greatest Navy which the world has ever seen.

The destructive energy in the field and afloat has multiplied many hundredfold since the time of the Napoleonic wars; both before and during the war the size of guns and the efficiency of explosives and shell increased immensely, and many new implements of destruction were added. Modern science and engineering enabled armies unprecedented in size, efficiency and equipment to be drawn from all parts of the world and to be concentrated rapidly in the fighting-line.

To build up the stupendous fighting organisation, ships have been taken from their normal trade routes, locomotives and material from the home railways, the normal manufactures of the country have been largely diverted to munitions of war; the home railways, tramways, roads, buildings and constructions, and material of all kinds have been allowed to depreciate. The amount of depreciation in roads and railways alone has been estimated at 400 millions per annum at present prices. Upon the community at home a very great and abnormal strain has been thrown, notwithstanding the increased output per head of the workers derived from modern methods and improved machinery. In short, we have seen for the first time in history nearly the whole populations of the principal contending nations enlisted in intense personal and collective effort in the contest, resulting in unprecedented loss of life and destruction of capital.

A few figures will assist us to realise the great difference between this war and all preceding wars. At Waterloo, in 1815, 9,044 artillery rounds were fired, having a total weight of 37·3 tons, while on one day during the last offensive in France, on the British Front alone, 943,837 artillery rounds were fired, weighing 18,080 tons—over 100 times the number of rounds, and nearly 540 times the weight of projectiles. Again, in the whole of the South African War, 273,000 artillery rounds were fired, weighing approximately 2,800 tons; while during the whole war in France, on the British Front alone, over 170 million artillery rounds were fired, weighing nearly 3½ million tons—622 times the number of rounds, and about 1,250 times the weight of projectiles.

However great these figures in connection with modern land artillery may be, they become almost insignificant when compared with those in respect of a modern naval battle squadron. The "Queen Elizabeth" when firing all her guns discharges 18 tons of metal and develops 1,870,000 foot-tons of energy. She is capable of repeating this discharge once every minute, and when doing so develops by her guns an average of 127,000 effective horse-power, or more than one-and-a-half times the power of her propelling machinery; and this energy is five times greater than the maximum average energy developed on the Western Front by British guns. Furthermore, if all her guns were fired simultaneously, they would for the instant be developing energy at the rate of 13,132,000 horse-power. From these figures we can form some conception of the vast destructive energy developed in a modern naval battle.

Engineering and the War.

With regard to the many important engineering developments made during the war, several papers by authorities are announced in the syllabus of papers constituting the sectional proceedings of this year's Meeting. Among them are "Tanks," by Sir Eustace d'Eyncourt; "Scientific Progress of Aviation during the War," by Dr. Bairstow; "Airships," by Lieut.-Colonel Cave-Brown-Cave; "Directional Wireless, with Special Reference to Aircraft," by Captain Robinson; "Wireless in Aircraft," by Major Erskine Murray; "Wireless Telegraphy during the First Three Years of the War," by Major Vincent Smith; "Submarine Mining," by Commander Gwynne; "Emergency Bridge Construction," by Professor Ingles; and "The Paravane," by Commander Burney. Accordingly it is quite unnecessary here to particularise further except in the few following instances:—

Sound-ranging and Listening Devices.—Probably the most interesting development during the war has been the extensive application of sound-listening devices for detecting and localising the enemy. The Indian hunter puts his ear to the ground to listen for the sound of the footsteps

of his enemy. So in modern warfare science has placed in the hands of the sailor and soldier elaborate instruments to aid the ear in the detection of noises transmitted through earth, water, air, or ether, and also in some cases to record these sounds graphically or photographically, so that their character and the time of their occurrence may be tabulated.

The sound-ranging apparatus developed by Professor Bragg and his son, by which the position of an enemy gun can be determined from electrically recorded times at which the sound wave from the gun passes over a number of receiving stations, has enabled our artillery to concentrate their fire on the enemy's guns, and often to destroy them.

The French began experimenting in September, 1914, with methods of locating enemy guns by sound. The English section began work in October, 1915, adopting the French methods in the first instance. By the end of 1916 the whole Front was covered, and sound-ranging began to play an important part in the location of enemy batteries. During 1917 locations by sound-ranging reached about 30,000 for the whole Army, this number being greater than that given by any other means of location. A single good set of observations could be relied upon to give the position of an enemy gun to about 50 yards at 7,000 yards range. It could also be carried on during considerable artillery activity.

The apparatus for localising noises transmitted through the ground has been much used for the detection of enemy mining and counter-mining operations. Acoustic tubes, microphones, and amplifying valves have been employed to increase the volume of very faint noises.

For many years before the war the Bell Submarine Signalling Company, of which Sir William White was one of the early directors, used submerged microphones for detecting sound transmitted through the water, and a submerged bell for sending signals to distances up to one mile. With this apparatus passing ships could be heard at a distance of nearly a mile when the sea was calm and the listening vessel stationary.

Of all the physical disturbances emitted or produced by a moving submarine, those most easily detected, and at the greatest distance, are the pressure waves set up in the water by vibrations produced by the vessel and her machinery. A great variety of instruments have been devised during the war for detecting these noises, depending on microphones and magnetophones of exceedingly high sensitivity. Among them may be particularly mentioned the hydrophones devised by Captain Ryan and Professor Bragg, being adaptations of the telephone transmitter to work in water instead of air. These instruments, when mounted so as to rotate, are directional, being insensitive to sound waves whose front is perpendicular to the plane of the diaphragm, and giving the loudest sound when the diaphragm is parallel to the wave front.

Another preferable method for determining direction is to use two hydrophones coupled to two receivers, one held to each ear. This is called the biaural method, and enables the listener to recognise the direction from which the sound emanates.

When the vessel is in motion or the sea is rough the water noises from the dragging of the instrument through the water and from the waves striking the ship drown the noises from the enemy vessel, and under such conditions the instruments are useless. The assistance of eminent biologists was of invaluable help at this juncture. Experiments were made with sea-lions by Sir Richard Paget, who found that they have directional hearing under water up to speeds of six knots. Also Professor Keith explained the construction of the hearing organs of the whale, the ear proper being a capillary tube, too small to be capable of performing any useful function in transmitting sound to the relatively large aural organs, which are deep set in the head. The whale therefore hears by means of the sound waves transmitted through the substance of the head. It was further seen that the organs of hearing of the whale to some degree resembled the hydrophone.

The course now became clear. Hollow towing bodies in the form of fish or porpoises were made of celluloid, varnished canvas, or very thin metal, and the hydrophone suitably fixed in the centre of the head. The body is filled with water, and the cable towing the fish contains the insulated leads to the observer on board the vessel. When towed at some distance behind the chasing ship disturbing noises are small, and enemy noises can be heard up to speeds of 14 knots, and at considerable distances. Thermionic amplifying valves have been extensively used, and have added much to the sensitiveness of the hydrophone in its many forms.

After the loss of the "Titanic" by collision with an iceberg, Lewis Richardson was granted two patents in 1912 for the detection of abovewater objects by their echo in the air, and underwater objects by the echo transmitted through the water. The principles governing the production and the concentration of beams of sound are described in the specification, and he recommends frequencies ranging from 4,786 to 100,000 complete vibrations per second, and also suggests that the rate of approach or recession from the object may be determined from the difference in the pitch of the echo from the pitch of the blast sent out. Hiram Maxim also suggested similar apparatus a little later.

The echo method of detection was not, however, practically developed until French and English scientists, with whom was associated Professor Langevin, of the College de France, realising its importance for submarine detection, brought the apparatus to a high degree of perfection and utility shortly before the Armistice. Now, with beams of

high-frequency sound waves, it is possible to sweep the seas for the detection of any submerged object, such as icebergs, submarines, surface vessels, and rocks; they may also be used to make soundings. It enables a chasing ship to pick up and close in on a submarine situated more than a mile away.

The successful development of sound-ranging apparatus on land led to the suggestion by Professsor Bragg that a modified form could be used to locate under water explosions. It has been found that the shock of an explosion can be detected hundreds of miles from its source by means of a submerged hydrophone, and that the time of the arrival of the sound wave can be recorded with great precision. At the end of the war the sound-ranging stations were being used for the detection of positions at sea, required for strategical purposes. The same stations are now being used extensively for the determination of such positions at sea as light-vessels, buoys which indicate channels, and obstructions such as sunken ships. By this means ships steaming in fog can be given their positions with accuracy for ranges up to 500 miles.

Among the many other important technical systems and devices brought out during the war which will find useful application under peace conditions as aids to navigation I may mention directional wireless, by which ships and aircraft can be given their positions and directed, and on this subject we are to have a paper in Section G.

Leader gear, first used by the Germans to direct their ships through the minefields, and subsequently used by the Allies, consists of an insulated cable laid on the bottom of the sea, earthed at the further end, and through which an alternating current is passed. By means of delicate devices installed on a ship, she is able to follow the cable at any speed with as much precision as a railless electric 'bus can follow its trolley wire. Cables up to fifty miles long have been used, and this device promises to be invaluable to ships navigating narrow and tortuous channels and entering or leaving harbours in a fog.

(*To be continued.*)

GENERAL NOTES.

Lectures for Teachers.—The "Handbook of Classes and Lectures for Teachers" for the session 1919-20, has just been issued from the L.C.C. Education Offices. These lectures are available for all teachers employed in the Administrative County of London on payment of a registration fee of 1*s*. for each course; from teachers outside that area an inclusive fee of 7*s*. is required in respect of each course attended. The prospectus, which may be obtained on application to the L.C.C. Education Officer, gives the syllabuses of a highly interesting list of ninety courses on a variety of subjects in Economics, History, Pedagogy, Phonetics, Science, English Language and Literature, Foreign Languages, etc.

British Toy Industry.—One of the members of the deputation of toy manufacturers who waited upon the President of the Board of Trade on September 5th mentioned that 20,000 workers are employed in the above industry. Toy producers, in addition to their own work, had produced during the war 25,000,000 eye-pieces and breathing valves for gas helmets, 20,000,000 fuse cylinders, 50,000,000 food containers, 8,000,000 base caps, 6,000,000 0·75 fuses, 48,000,000 steel cap chambers for primers, 5,000,000 shell clips, and 2,000,000 fuse delay holders.

Institution of Automobile Engineers.—The first meeting of the session of this Institution will be held on October 1st at the Royal Society of Arts, when Mr. Thomas Clarkson, M.Inst.C.E., will deliver his Presidential Address. The papers promised for the session include the following: "Car Design and Car Usage considered from the Standpoint of the Majority of Owner-Drivers," by Mr. E. N. Duffield; "Producer Gas as Applied to Vehicle Propulsion," by Lieut.-Colonel D. J. Smith; "Volatile Fuel Supplies," by Dr. W. R. Ormandy; and "American Practice," by Mr. A. Ludlow Clayden.

Institute of Metals.—The papers to be presented at the annual autumn meeting of the Institute of Metals in Sheffield, on September 24th and 25th, will include one by an American metallurgical engineer, Dr. Zay Jeffries, of Cleveland, Ohio, on "The Micro-Mechanism of the Ageing of Duralmin," a subject of great practical interest to all concerned with the working or use of an aluminium alloy that has played a very important part in aeronautical engineering during the war. Dr. Jeffries has come over to this country in order to be able to present his communication in person to the Institute at its Sheffield meeting.

Aviation in India.—One of the largest aviation firms in England has already asked permission from the Indian Government to commence commercial flying in India. It wishes to start at once and to carry passengers and mails along the main routes. It offered to do this without any subsidy from the Government whatever. Unfortunately as yet the Indian Government will not give permission. A large industrial firm in Calcutta is at present negotiating for a concession to build a rope-railway over the mountains from India into Kashmir, and it is intended to run an aeroplane service in conjunction with this rope-railway. Passengers and light merchandise will go by aeroplane, and the heavy baggage of the passengers, together with bulky merchandise, will be taken by the rope-railway.—"*Times*" *Trade Supplement.*

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—September 12, 1919.

No. 3487. SEPTEMBER 19, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Telegrams: "Vacuum, Trowbridge." *Telephone:* 113 Trowbridge.

BURNETT MOTOR TYRES

Sole Proprietor:

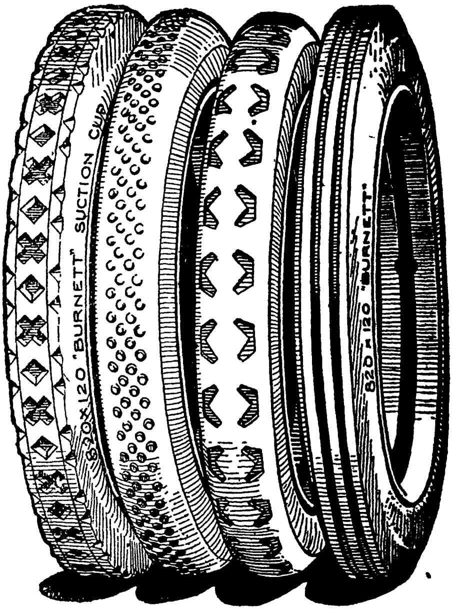
CUTHBERT BURNETT.

Shetland,
6th May, 1918.

Gentlemen,—

I would thank you to send me your list of tyres, etc. I may say I had one of your tyres some time ago, which gave me every satisfaction.

W. B.



Suction-Cup. Studded. Dauntless. Ribbed.
Patent 14519/10. Reg. No. 642307.

London, N.,
21st June, 1918.

Dear Sirs,—

We return you a tyre, No. 49404, 875 × 105, which may possibly be of interest to you. It has run on the off-side front wheel of a 33-cwt. lorry 7,808 miles without being taken off the rim: it was then punctured; afterwards it ran 1,519 miles, making a total of 9,327 miles. This mileage is considerably more than double the mileage of any other tyre we have had as yet.

POWELL & CO.

COMPLETE PRICE LIST ON APPLICATION TO

The BURNETT Motor Tyre & Rubber Co.

Yerbury Mills, Trowbridge, Wilts.

London Depot - - 71, MORTIMER ST., GREAT PORTLAND ST., W. 1.

CONTRACTORS TO THE BRITISH AND FRENCH WAR OFFICES, Etc.

Journal of the Royal Society of Arts.

No. 3,487. VOL. LXVII.

FRIDAY, SEPTEMBER 19, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROBLEMS OF FOOD AND OUR ECONOMIC POLICY.

By Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S.

Lecture III.—Delivered April 14th, 1919.

Ye are the salt of the earth: but if the salt have lost its savour, wherewith shall it be salted? It is thenceforth good for nothing but to be cast out and to be trodden under foot of men.

Urea, to which it is the ultimate fate of our nitrogenous food to be reduced, an important structural unit in the proteins in the form of arginine, was first prepared artificially by Wöhler in 1828. Although it is one of the simplest of known nitrogenous compounds, not only do chemists still disagree as to its structure but usually, in referring to it as carbamide, assign both a name and a formula which are certainly both misrepresentations of its character. Such is the irony of life even in science. And we are ignorant of the process by which it is formed and passed into the bladder; the manner in which it is concentrated into urine is one of the standing wonders of animal chemistry; however spendthrift we may be of our shibboleths —adsorption, ions, osmotic pressure and the like—we cannot face the facts with any rational explanation. And yet such problems must be solved, if we are to secure even slight control of the vital mechanism.

Wöhler's great achievement was the deathblow to the prevalent conception that the compounds characteristic of plants and animals were formed under the influence of a vital force —whence the term "organic" chemistry. The idea was not finally disposed of, however, until it was shown, a few years ago, that fermentation was not necessarily—as Pasteur had always so stoutly affirmed—a process correlative with life.

The progress since 1828 has been stupendous: the astounding fabric of structural organic chemistry has been entirely reared in the interval. But our knowledge of the nature of food materials and of the process of digestion is of quite recent growth. We owe the advance very largely to the philosophical constructive studies of Emil Fischer and his school. Not only are fourteen of the sixteen conceivable forms of hexaldose (glucose) now known but their minute anatomy has been revealed in all its naked tracery—at least in so far as this can be symbolised on paper. And let me once more insist that the most important direct clue we have to the nature of the vital mechanism is afforded by the parsimonious selection by Nature of her constructive and reserve materials.

In the case of the carbodydrates, glucose comes first in importance, then fructose; mannose and galactose come next but after a long interval. Glucose, mannose and fructose are all interconvertible. Galactose is merely glucose in which a hydrogen atom and an OH group attached to one of the carbon atoms are transposed in their relative positions; this fact may be all significant of the process by which these hexoses are formed: it at least seems to suggest that in some cases they are produced by the coalescence of two C_3 groups (from glyceraldose) and that the passage from one to the other—probably in the mammary gland—is effected by hydrolytic cleavage of the molecule and reassociation of the sections in such a way that the newly introduced OH group of the aldehydrol is retained whilst that originally present is removed. This galactose-glucose problem is of more than ordinary interest and one that both deserves and requires investigation.

Formation of Fat.

Glycerol is constantly met with, both in animals and plants, in the form of fats; in the case of the former it cannot well be produced

otherwise than by the degradation of glucose. The fat molecules, apparently, are too large to pass from the digestive tract directly into circulation; prior to entry, they are resolved into glycerol and fatty acid: but though they pass the doorways in such separate form, the scattered elements are at once reassembled and fat reconstituted. As there are characteristic differences between fats of different animals, the reconstitution would seem to be, in some measure, a directed process, though it may be that the acids are merely supplied in different proportions; the subject is one of which we are but sparely informed.

The reconstitution of fats must, however, be a process to which the animal contributes a share beyond that afforded by the fat; glycerol, being very soluble in water, during digestion must be hurried away faster than the fatty acids which crowd through with it; the glycerol should, therefore, in considerable measure, escape reconstitution into fat. This means that an excess of glycerol must be provided at the centres at which fats are reformed: perhaps it is on this account important that a certain ratio of fat to carbohydrate is desirable in a diet.

Early in the war, at the request of the Board of Agriculture, I undertook an inquiry into the suitability of fatty acids produced from whale oil as a foodstuff for stock—pigs and cattle. Large quantities of low grade fats were being directly hydrolysed apart from soap works, in order to obtain glycerol; the question was whether the acid product could be used in substitution for the fats in ordinary oil-cake by feeding it with seed residues from which the fats had been extracted. Feeling, for the reasons given, that it was unnecessary to deal with the question otherwise than from the practical side, the academic issue being settled, I at once entered into arrangements for large-scale feeding trials. Most happily, Messrs. Bibby and Co., of Liverpool, the well-known seed crushers and makers of cattle foods, at once agreed to undertake the preparation of suitable mixtures and to feed these systematically at their farm, where they were accustomed to test their own products. The only difficulty met with was in securing a suitable medium: degreased palm-kernel meal could not be used on account of its mechanical qualities; it is ground in such a way that the particles are sharp and cutting and therefore the animals decline to eat it. Cotton-seed meal proved to be a satisfactory medium. Both pigs and milch cows were fed over a considerable period on a ration practically free from fat other than that presented in the form of fatty acids. The pigs seemed even to prefer their fat in this form and both pigs and cows throve normally on the artificial diet; when the pigs were killed, their flesh was indistinguishable from those fed in the ordinary way.

These results are incontrovertible proof that the animal organism has the power of producing glycerol at all events in response to such needs as the presence of fatty acids imposes; and that the fatty acids, being so weak as acids and so slightly soluble, are not productive of harmful effects. There is little doubt that, if supplied in palatable form, they could be used as human food; indeed, it has recently been stated that the Food (War) Committee of the Royal Society appointed a fat committee of two physiologists to look into the question and that this committee, after making various laboratory experiments, fed itself or its assistants on fatty acids without suffering any ill effects.

There is no doubt that much remains to be learnt of fats and their assimilation by the animal organism, particularly of the relation of ingested to reproduced fat and to the changes which the fats undergo in the system. But such inquiries, to be fruitful, must be in experienced, thoroughly competent hands and under very special direction.

To give an example, it is known among cattle feeders that linseed cake is of special value in finishing stock. Linseed oil differs from the oils in other cattle foods in being a drying oil and contains a large proportion of unsaturated acids. Probably, however, the difference in value between linseed and other cakes is to be sought for in the presence of some other constituent or constituents peculiar to linseed rather than in peculiarities of its fatty constituents. To determine this issue, it is desirable to institute systematic feeding trials with materials made by degreasing the various oil cakes and interchanging the extracted oils.

Influence of Environment.

To return to glycerol and its production in the animal system, it is a well known constant product of ordinary vinous fermentation, as Pasteur was the first to show—but only to the extent of at most about 3 per cent. calculated on the sugar converted. According to a recent American statement, the amount produced can be raised to about 20 per cent.—merely by maintaining the solution alkaline by adding sodium carbonate to the fermenting liquid at

intervals. The discovery that so large a proportion of glycerol can be obtained is not only remarkable but a striking illustration of the influence that environmental conditions may have on vital processes.

It is perhaps significant that molasses was the raw material used in these experiments, as this is rich in fructose. Fructose, it is known, undergoes change in two directions:—

$CH_2.OH$		$CH_2.OH$		$CH_2.OH$
$CH.OH$		$CH.OH$		$CH.OH$
$CH.OH$	$\rightleftarrows$	$CH.OH$	$\rightleftarrows$	$CH.OH$
$CH.OH$		$CH.OH$		CO
$CH.OH$		CO		$CH.OH$
COH		$CH_2.OH$		$CH_2.OH$
Glucose		Fructose		Glutose

The proportion of glutose present in a fermenting solution of fructose should therefore be greater than that in a corresponding solution of glucose: if such be the case and the conversion into glycerol take place through glutose, the special value which cane sugar apparently has as a food material may conceivably be due to the fact that it affords an immediate supply of fructose.

It is said that fructose "is not dealt with in the human organism in the same way as glucose is. A patient whose power of burning glucose is seriously impaired may yet utilise fructose in the normal manner" (Garrod). In view of the suggestion made in the previous lecture as to diabetes, this statement is of special interest and importance; the problem is clearly one that should be made the subject of special study.

The fats, though substances of high molecular weight, are simple in structure and fairly well understood. The carbohydrates, if not simple in structure, are at least built up of similar primary units which are of relatively simple structure. Proteins, however, are of singular complexity, in that they are composed of a very considerable number of unlike though genetically related units; the list, it is clear, is not yet fully made out. This diversity and complexity of structure is undoubtedly at the root of the value of the proteins as the formative materials from which the living mechanism is built up in all its wondrous details—yet strictly according to pattern. Again, as in the case of the carbohydrates, a narrow selection has been made by Nature: for example, only a limited number of the possible amino-acids are met with among the cleavage products of the proteins.

Our knowledge of the nature of the proteid food materials and of the process of digestion is of very recent growth. It is not long since we thought of their ingestion into the circulatory system in large units—as peptones; the idea that proteins are broken down into simple amino-acids and similar substances during digestion and that assimilation is merely a process of the reverse order is mainly the outcome of the exact inquiries carried out by Osborne in the United States of America and by Emil Fischer and his school.

Notwithstanding the variety of building materials at hand, both plant and animal consistently follow a definite constructive policy, from which the departures are relatively few —though perhaps more numerous than is generally supposed, as abortions are not often brought to public notice; but when departures take place, they seem rather to be the consequence of irregular development on normal lines than departures from principle: even the poet shows that he has seen this, in saying—

"So careless of the single life,
So careful of the type she seems."

Modern Mendelian studies have taught us more than ever to believe in the fixity of types —they have carried us further in leading us to suppose that this or that characteristic is the expression of the presence of a particular factor: in point of fact, in taking this step, the biologists have but assimilated ideas which have long been current doctrine in chemistry. The question as to whether change in environment can determine change of type is one of great consequence in connection with epidemic disease. Adami, in particular, has contended of late that such changes do occur and has advanced arguments on the chemical side in support of his thesis: but it is difficult to regard his contentions seriously, as the point of view from which he has dealt with the subject is far too general and his treatment lacks technical feeling.

It has been asserted that a yeast which does not ferment galactose may acquire the habit if it be grown in a medium containing this hexose: but it does not appear that the change has been effected starting from a single cell; what may well have happened is that a very minute proportion of cells originally present may have been favourably influenced by the presence of galactose, so that eventually sufficient have been developed to make their presence felt. Like nations, yeasts are mixed populations and it is to be expected that one or other element may be brought to the fore by proper

encouragement. It has been shown within recent years that raffinose is very widely spread in plants, though present usually in small proportion: as this yields galactose on hydrolysis, together with cane sugar, its constant presence would furnish the pabulum to maintain a small proportion of organisms requiring galactose in being, though not to an extent which would render them conspicuous in a yeast. But that environmental changes might affect the virulence of an organism seems possible, in view of cases such as that afforded by the increased production of glycerol already referred to and by the greatly increased activity of urease in presence of an excess of carbonic acid. However, the problem is one which can be treated experimentally and it is to be hoped will receive due attention.

Advitants.

The recognition of advitants as indispensable factors in our diet is the logical outcome of the inquiries made in recent years with artificial dietaries to test the possibility of this or that individual protein being used in substitution for ordinary protein foods; but the subject has only acquired importance since it has been recognised that diseases such as beri-beri and scurvy are the outcome of definite deficiencies and may be easily cured, in their early stages, if such deficiencies be met.

Eijkman's observations made in Batavia, Java, prior to 1897, published in summarised form in June, 1897, in *Virchow's Archiv*, on a beri-beri disease in fowls, come first in importance. His attention was called to the matter by the spontaneous outbreak of disease, in the small stock of fowls in his laboratory, closely resembling beri-beri in its symptoms, involving nervous breakdown and ultimate death. Experiment appeared to show that it was not an infectious disease. Suspicion was eventually cast upon the diet as the cause, when it was ascertained that the fowls had been fed entirely on cooked rice, remaining over from the hospital kitchen, after it had been kept several days. This had been the diet from June 10th to November 20th, after which date they were again fed on their usual diet of raw, unhusked rice grain. Disease appeared on July 10th—an incubation period of about a month—and came to an end towards the close of November. It was then found possible to bring on the disease, at any time, by feeding the fowls on cooked rice, whether freshly cooked or stale, whatever its origin. But rice which had only been decorticated, not polished and so deprived of the outer silvery skin usually removed as bran, did not give rise to the disease, nor did the symptoms set in if sufficient of the rice-bran were added to the cooked polished rice. At first the fowls recovered when fed on a mixed diet of meat and starch but eventually—though after a much longer interval—they succumbed even on this diet. Strange to say, they did well on potato starch and when fed either on meat alone or on meat and milk or cane sugar.

The explanation finally preferred by Eijkman was that the polyneuritic condition was in some way conditioned by starch—perhaps through the formation of a nerve poison, within the alimentary tract, under the influence of lower organisms, to which the rice-bran furnished an antidote. The harmless character of potato starch was accounted for by the assumption that this perhaps was more resistant than rice-starch.

The results obtained by the study of fowls led Eijkman to inquire into the conditions which favoured the appearance of beri-beri in the native prisons in Java. Information was obtained from about 200 prisons and from the neighbouring island of Madura. The rice used in some was white polished rice, whilst others used merely decorticated red rice. Out of 27 prisons using red rice, only one reported beri-beri, whilst of those using polished rice 36—more than 50 per cent.—were affected.

A full Government inquiry was then instituted. It appeared that three forms of rice diet were in use: in Case 1, the rice was partially decorticated, the bran layer being retained either entirely or to the extent of at least three-quarters. In Case 2, this rice was mixed with that used in Case 3, viz. polished rice from which the bran layer had been removed either entirely or to the extent of at least three-fourths.

The number of prisoners considered was over a quarter of a million—279,623 in all. The incidence of disease was as follows:—

1 . . .	1 in 10,000
2 . . .	1 in 416
3 . . .	1 in 39

No connection could be established between the occurrence of the disease and environmental conditions.

Very little notice was taken of Eijkman's observations but attention was again directed to the subject when Funk in 1912 showed that it was possible to cure polyneuritis in pigeons by an extract made from rice polishings.

His contention that he had isolated the active substance, unfortunately, was not confirmed. As it was in this connection that the term vitamine was first introduced, exception has naturally been taken to its use, not only as premature but as committing us to a conclusion for which there is no justification.

I have referred thus fully to Eijkman's work because it appears to me to afford an example that deserves imitation. We need a similar but more exhaustive inquiry into the conditions in some of our public institutions and boarding schools, in which special care is given to the preparation of the food. Many must have been struck by the lassitude which often prevails, in a more or less marked form, as well as by the anæmic appearance of the children in some schools; the anæmic tendencies of the domestic servant are also well known.

"Barlow's disease," it may be pointed out, was discovered among children of the upper class, "in healthy homes, among good surroundings."

Gowland Hopkins was led, as early as 1906, by his studies of the effect of artificial dietaries, to put on record his views as to their insufficiency and to insist on the importance of unrecognised minor constituents in the following unmistakable terms:—

"No animal can live upon a mixture of pure protein, fat and carbohydrate; and even when the necessary inorganic material is carefully supplied, the animal still cannot flourish. The animal body is adjusted to live either upon plant tissues or the tissues of other animals and these contain countless substances other than the proteins, carbohydrates and fats. Physiological evolution, I believe, has made some of these well-nigh as essential as are the basal constituents of diet; lecithin, for instance, has been repeatedly shown to have a marked influence upon nutrition and this just happens to be something already familiar and a substance that happens to have been tried. The field is almost unexplored; only it is certain that there are many minor factors in all diets of which the body takes account. In diseases such as rickets and particularly in scurvy, we have had, for long years, knowledge of a dietic factor; but though we know how to benefit these conditions empirically, the scale errors in diet are to this day quite obscure. They are, however, certainly of the kind which comprises these minimal qualitative factors that I am considering. Scurvy and rickets are conditions so severe that they force themselves upon our attention; but many other nutritive errors affect the health of individuals to a degree most important to themselves and some of them depend upon unsuspected dietic factors."

The further inquiries undertaken by Hopkins to give a full quantitative basis to his results were not described until 1912. Meanwhile, others had advanced in the same direction. It had been found by Stepp that food which had been extracted with liquids which were solvents of fats and fat-like substances could not maintain life in mice, although, if the extracted material were returned, the foodstuff became satisfactory again. That the advitant concerned was something soluble in fat and not fat itself was rendered evident by the fact that when ether—a good solvent of fats—was used to extract the food, mice could live on the residue, whilst food extracted with alcohol was useless.

Again, Osborne and Mendel had found that by evaporating the liquid left after removing, as far as possible, the proteins from fat-free milk, a residue was obtained which rendered an artificial dietary one which promoted rapid growth in rats which had remained stationary in weight on the dietary to which it was added. But this residue formed nearly 30 per cent. of their dietary.

Hopkins used actual milk but it amounted only to from 1 to 4 per cent. of the whole food eaten. The basal diet on which he fed the rats consisted either of Merck's pure casein or the commercial casein known as protene, together with starch which had been thoroughly extracted with alcohol and specially purified lard. In all cases, the amount of the basal food eaten was sufficient to meet the energy requirements. In the experiments with pure casein, growth fell off after a time; in the experiments with protene, the reduction of growth was less apparent. Doubtless, the difference was due to the retention of small amounts of the active material in the protene.

When a minute proportion either of an extract prepared from the expressed juice of mangolds (0·1 gram per rat per diem), or of protein-free extracts of milk solids or of yeast, was added to the food, growth was considerably accelerated.

As to the nature of the effect produced, the conclusion arrived at by Hopkins was that the amount sufficient to secure growth being so small the added substance probably exercised a catalytic or stimulative function rather than that of a structural unit. Stimulation

of the internal secretions of the thyroid and pituitary glands, which are believed to play an important part in digestive processes, might be legitimately considered as possible causes of the effect. It was also conceivable that the influence exercised on the growing tissues might be a direct one. To attribute such indispensable functions to specific conditions of the dietary was indeed foreign to current opinion upon nutrition but so also was the experimental fact that young animals may fail to grow even when they are daily absorbing a sufficiency of formative material and energy for the purposes of growth.

In this connection, attention may be called to the circumstance well known to stock feeders that some animals are good, whilst others are bad doers, that is to say, some respond to fattening whilst others do not. In our own case, those of spare build are often, if not usually, the grosser feeders. It may be, therefore, that interference with growth is not so much a positive or direct effect but rather the consequence of an acceleration and enhancement of the oxidative process.

Later inquiries have carried the story to a further stage—to the recognition of two different advitants as growth factors, the one soluble in fats and alcohol, the other in water, known respectively as the Fat Soluble A and Water Soluble B; further, it is probable that the water-soluble growth factor, if not identical with the "anti-neuritic" substance present in rice polishings, at least stands in very close relation to it. Hopkins' contention that the amounts of the water-soluble substance required to maintain growth are minute, have been confirmed in every particular. All attempts made to isolate the substance have been failures but it has been shown that it adheres strongly to various substances which are precipitated from the solutions in its presence. Eijkman's observations that potato starch and even ordinary milk sugar did not induce polyneuritis in fowls may therefore be explained as probably the consequence of the retention by these substances of a sufficient amount of the advitant to satisfy animal needs.

It has been pointed out by McCollum and Davis that, in the process of polishing rice, not only is the bran layer removed but the embryo, which is easily detachable, as well. As the wheat embryo is rich in the water-soluble accessory and this appears to be absent from the part of the wheat kernel which makes up bolted flour, there is little doubt that the curative effects of rice polishings and of extracts made from these is at least mainly due to the presence of the embryo.

In the case of rats, in the absence of the water-soluble advitant, the food consumption, in all probability, is reduced to that required to maintain thermal requirements. Increased appetite may be excited by the addition of flavouring agents such as meat extracts but there is no corresponding growth unless the advitant be also supplied. If the diet be otherwise adequate, the extent to which growth takes place appears to be proportional to the supply of advitant. The length of time during which rats may be maintained on diets deficient in advitant seems to be directly proportional to the age at which the restriction is imposed, the effect of a deficiency being specially marked in the earlier stages of growth. Breeding power is adversely affected.

It remains to refer to recent work in scurvy, so long the scourge of the Navy, a disease which always accompanies famine and one that has been rife in the armies in the East in the late war; under ordinary conditions it is of far more frequent occurrence, in a more or less concealed form, than is commonly suspected. The recent work of Harden and Silva, in particular, carried out at the Lister Institute, appears to have afforded final proof that this also is a deficiency disease, due to absence from the food of a special advitant different from those referred to previously. This advitant is easily destroyed by heating and in this respect differs from the fat-soluble and water-soluble antineuritic and growth advitants. It is present in fresh fruit and vegetables and also—though to a minor extent—in fresh milk but not in cereal grains; unfortunately, it is destroyed in drying vegetables.

Harden and Silva have not only confirmed the observations of previous observers with regard to the need of the two "antineuritic" and growth factors but have also shown that rats fed on a diet containing the antiscorbutic factor in addition grow better than those from whose diet this factor is absent. Perhaps the best source of the antiscorbutic advitant is lemon juice, one of the materials used with such success by Captain Cook to check scurvy. In later years, to encourage the growth of limes in the West Indies, lime juice was issued to the Navy in place of lemon juice but fell into disuse when it was found to be ineffective. Recent observations have shown that lime juice contains far less of the antiscorbutic advitant

than lemon juice and apparently it loses what virtue it has on keeping.

Lemon juice is a particularly powerful curative agent of scurvy but it suffers from the disadvantage, especially in the case of children, that it contains a large amount of citric acid. Harden and Silva have rendered important service in showing that the acid may be removed, by means of calcium carbonate, without affecting the advitant and that the juice may even be concentrated if only it be maintained acid.

Effects of a Deficiency of Advitants on Specific Glands.

An exceptionally complete inquiry into the effects produced on the various glands by a deficiency of advitants has been carried out at the Pasteur Institute of Southern India, Coonoor, by Lieut.-Colonel McCarrison. An account of his results is to be found in the latest number of the *Indian Journal of Medical Research* (Vol. VI. pp. 275-355, January, 1919). Being in the tropics, Col. McCarrison has had unusual opportunities of dealing with the morbid states caused by complete deprivation of the accessory food factors. He is led to believe from his clinical experience that many minor maladies of children especially are to be associated either with the incomplete provision of these substances in the food or with their incomplete assimilation. The laboratory experience gained during the course of the research has been of value, he states, in enabling him to deal with cases of bilious vomiting, mucus disease and other metabolic disorders of childhood. He, therefore, draws the attention of physicians, especially those connected with the great children's hospitals, to the effects of a deficiency of advitants, not only on the central nervous system but also on the liver, the pancreas, the spleen, the pituitary, the thymus, the thyroid, the reproductive organs and the adrenal-sympathetic system the functional perfection of which is of such vital importance to the growing child.

In his experiments he fed a large number of pigeons solely on polished rice, *i.e.* a diet consisting mainly of starch—less than 10 per cent. of protein—destitute of the so-called accessory food factors; 168 of the birds developed *polyneuritis gallinarum*. The heart's blood and internal organs of 142 birds so fed were examined at autopsy: 94 showed signs of septicaemic infection, 48 being sterile; 4 out of the 142 had tubercular disease either of the lungs or of the abdominal viscera or of both. Seventy-two pigeons were used as controls: septicaemic infection was detected in only 6 out of 63 of these; 2 had tubercular peritonitis.

It is clear from these results that other agencies, in addition to the lack of advitants, may contribute to the morbid states which are initiated by dietetic deficiencies. The four chief factors appear to be (1) inanition, (2) excess of starch in the food, (3) lack of advitants, (4) pathogenic. Emphasis is laid on the need of demonstrating the sterility of the blood and tissues before basing conclusions on the influence of food factors alone; the thymus, the thyroid, the adrenals and the testicles are highly susceptible to the influence of bacteria. Unless their absence be proved, conclusions with regard to these organs may be erroneous.

The effects of feeding pigeons on milled autoclaved rice is similar to that produced by starvation, inanition being only less acute in its progress in the latter case. Excepting the adrenals, which become much enlarged with increase of their adrenalin content, the organs generally undergo atrophy in the following order: thymus, testicles, spleen, ovary, pancreas, heart, thyroid, liver, stomach, kidneys, pituitary.

The manner in which the testicles are reduced and the adrenals enlarged is particularly striking; in fact, "profound atrophy of the reproductive organs is an important consequence of vitamine deficiency."

Colonel McCarrison expresses the opinion that too great significance is often attached to the destruction of the advitants by heating and too little to other possible etiological factors in the genesis of morbid states in the presence of a deficient dietary. A considerable proportion of the pigeons survived, during periods of fifty to sixty days, a diet consisting solely of rice which had been subjected to a degree of heat (130° C.) far in excess of that reached in the process of cooking human food. In prevention experiments designed to determine the antineuritic value of particular foodstuffs, by adding these to a polished rice dietary, prevention can only be reckoned to have been successfully accomplished if adult pigeons show no nervous symptoms during periods of 100 to 120 days. The time limit of 50 to 60 days now accepted appears to be too short. The experiments afford only one case of comparatively rapid onset of neuritic symptoms in the pigeons whose organs were demonstrated to have been sterile at the time of death. It is

clear, to use Colonel McCarrison's words, that "vitaminic deficiency renders the organism very liable to be overrun by the rank growth of bacteria."

In a later communication (*British Medical Journal*, August 16th, 1919), Colonel McCarrison has shown that in the case of dying guinea-pigs fed on a scorbutic diet of crushed oats and autoclaved milk, the adrenals are approximately double the weight of those in healthy animals but contain less than half the amount of adrenalin. He states that in healthy pigeons the total amount of adrenalin per gramme of gland is approximately ten times than in healthy guinea-pigs. But in pigeons fed on an incomplete diet, the amount found varies according to the class of advitant in defect. These results are of special interest as bearing both on the problem of "constitution"* and that of diet as affecting health.

Sacrifice of Savour.

The point of chief importance to which attention may be called in terminating this brief and inadequate summary of recent work concerning advitants, is that during recent years attention has at last been directed into fruitful lines of inquiry, of great promise, from the pursuit of which we may hope to arrive at a rational understanding of the processes of nutrition and the conditions of health, so that our needs may be properly met and the well-being of the masses secured in so far as this is dependent upon diet. Far too long we have worshipped at the microscope; mere morphology has usurped attention far too exclusively: the study of function should now come to the fore and the prevention of disease by provision of healthy conditions should count higher than its cure when contracted.

Our tendency is to over-use our knowledge—to use it too absolutely, without reflection, as though it were complete; and in modern times the march of knowledge has been so rapid, the new applications so numerous, that it has been impossible for the community to count the cost of its advances and to consider the wisdom of always following its leaders. The extent to which we have adopted new fashions is not realised nor are the effects of the changes upon our well-being in any way taken into account; in the main, convenience alone is consulted. The use we have made of science is in not a few respects unscientific.

Merely to suit the convenience of the kitchen and to avoid the use of the rolling-pin, even salt has been deprived of its savour, an expensive proprietary substitute being now supplied as a dry powder to which the tongue only slowly responds.

Jams are no longer home-made and in consequence either much over-boiled or over-sweetened, to ward off moulds and bacteria. Too frequently they are sophisticated with inferior materials other than fruit.

But the great reformer of recent times has been the chemist Pasteur—the extent to which he has influenced our doings is astounding. He first interfered with long established practice when he showed why wines occasionally passed into vinegar and that the intrusive organisms to which the change was due might easily be killed off by heating: forthwith wines were sterilised and the *Grand Vin*, the result of some fortuitous concourse of organisms, became a great rarity; the quality of wines was thereby reduced to a low general average, though of course much was saved from the sewer. Beer suffered a like fate, though on the whole the changes were much to the public advantage.

But the real harm was done when milk was tampered with. The occasional resort of the dairyman to the cow with the iron tail was taken far too seriously; when the measure was introduced to counteract his aqueous leanings and the public analyst was brought into existence, the struggle for a definition of quality led to the introduction of an average value as a standard; this was sufficiently below the good cow's estimate of what was proper to permit of "lawful" dilution. Dilution became a general practice; the public suffered less from occasional dishonest tradesmen but it was deprived of the advantages up till then derived from dealing with the large body who were honest purveyors of the natural article. The blow was made all the heavier by the introduction of clever engineering appliances for the separation of cream. Then Pasteur's teaching became operative once more, aided this time by Koch: milk was not only diluted but also sterilised. Some lives may have been saved but the step has undoubtedly been productive of untold misery. Not a few of us have long held, on general grounds, that a material

* In this connection, it is noteworthy that Professor Keith, last week, in his address to the Anthropological Section of the British Association at Bournemouth, dealing with the "Differentiation of Mankind into Racial Types," developed the thesis that the differences shown by the Negro, the Mongol, and the European are the consequence of differences in the activities of the various glands: he is of opinion, for example, that the pituitary gland plays a predominant part in shaping the face and body form of the European.

produced as milk is cannot be heated above blood-heat without diminishing its dietic value. Recent observations show indeed that the antiscorbutic advitant, which is none too abundant a constituent, is affected, although apparently the fat-soluble antirachitic and water-soluble antineuritic factors are not destroyed; but difficulties have been encountered in localities where the milk supply has been systematically sterilised and it may well be that it suffers in quality in ways not yet elucidated.

The inquiries thus far held into the effect of sterilising are in no way satisfactory and open to criticism on account of their incompleteness and unscientific character. The risks from typhoid and other similar infection are now slight and the main object of sterilising milk is to secure the destruction of the organism which conditions tubercular disease. But it may well be that in destroying some one or other mysterious constituent of the advitant class, the food value is so lowered that effects are produced which render the system specially sensitive to tubercular infection: such infection seems always to be with us apart from milk. Moreover, when milk is sterilised, the lactic organism is destroyed and it becomes a particularly favourable nidus for the growth of putrefactive organisms: it is therefore a potent cause of infantile diarrhœa.

Pasteur's teaching has also borne fruit in instructing us how to preserve food materials generally, by sealing them up in closed vessels, care being taken at the time of closing to sterilise the contents by heating; it is more than probable that not only are the advitants such foods contain to some extent destroyed in the process but that they are further affected during the long period of storage to which such foods are often subject. If cold storage does not affect flesh foods in this way, it at least has the disadvantage that the changes are kept in abeyance which naturally take place when meat is "hung" in the old way, changes which greatly improve its texture and flavour and thus add to its palatability; moreover, it permits of lower grades of quality being put upon the market than were formerly countenanced.

Then oatmeal, a magnificent whole food, especially when used together with milk, has been largely displaced by white bread made from germless flour, which we now know to be almost entirely deficient in advitants.

Lastly, we are substituting margarine made largely from vegetable fats for butter. The fat-soluble advitant to which I have so often referred is present in milk and therefore in butter, also in animal fats, though apparently in some more than others and in cod-liver oil; but in few vegetable fats, arachis and castor-oil being, I believe, the only two in which it is known to occur. Even margarine made directly from vegetable fats is therefore deficient in one of the most important of the advitants; it is probable also that when animal fats are used in its preparation, the advitant is in part if not wholly destroyed in the process of manufacture. Children are therefore likely to suffer if deprived of butter, especially if they have little or no milk. Recent observations by Mrs. Mellanby have shown that the teeth are not properly developed in the absence of the fat-soluble advitant; and rickets is clearly also a disease which is conditioned by its absence.

Much is yet to be learnt with regard to the production of advitants; there is reason to believe that they are primarily formed as vegetable products, not by animals. The fat-soluble antiscorbutic factor is said to be absent from pig's lard but probably the search made for it is insufficient. A full inquiry into this issue is an urgent need. Pigs are fed in queer ways and it may be that the advitant is acquired from some foods, not from others. It may be asked, for example, does grass-fed pork differ from that raised on town pigwash? If so, do grass pastures which are in repute as fattening grounds, either for cattle or sheep, differ in this respect from those which cannot be so used? We have yet everything to learn with regard to the value of animal foods and of vegetable foodstuffs of different kinds grown under different conditions. The production of a lard rich in advitants would be a great step in advance.

Milk Supply.

But our most imperative need is an increase in the milk supply; and not only should the quantity be increased but the quality also. Much has been done, of late years, to improve the supply but, as ever, the efforts have been individual and sporadic; we cannot any longer afford to play with the problem: there must now be properly directed, organised action.

Mr. Robert Mond has paid particular attention to the problem during the past dozen years, having undertaken the supply of pure milk to the Infants' Hospital, Vincent Square, Westminster, from his farm at Combe Bank, Sevenoaks. The conditions to be met have been fully established. It is clear that for the

purposes of public supply, milk should always be obtained by clean milkers from clean cows in a clean place. It should be received in sterilised vessels and these vessels should at once be transported to a central receiving station, where the milk should be sampled and immediately refrigerated well below 45° F. From these central stations, which for preference should be situated near railway stations or otherwise conveniently accessible for motor transport, the chilled milk should be sent in the largest convenient tank wagons to the dairies situated in centres of consumption, where again refrigerating machinery should be installed. The cooling and sterilising stations should be so situated that the milk would be received from the farms within two hours of being milked, so that no preliminary cooling at the farm would be requisite. As cooled milk maintains its qualities during a considerable period, the traffic could be arranged to suit the convenience both of the railway companies and of the distributors. Preservatives should never be used but the greatest care should always be taken to keep the milk only in effectively sterilised vessels.

One of the main reasons for the inefficient milk supply from which we have suffered has been the inability of the consumers to criticise. As long as users are willing to pay for a dirty article, whether in a bottle or in a tin, the same price as for a pure article, with only an occasional complaint, there has been no inducement for purveyors to incur the expense necessary to produce a higher standard article. Mr. Mond's experience is based on that of some 5,000 mothers who visit the out-patients' department at his infants' hospital: it is that having learnt to recognise good milk—by taste, smell and its curdling power with rennet—they have found very little difficulty, after using appropriate language, in obtaining from the existing dairies scattered all over the slums and suburbs of London, a suitable milk for their babies; it is by the spread of such knowledge and the will of insisting on having the article which is required that the greatest progress can be made in attaining a higher standard for milk.

Proper conditions of keeping all cows should be enforced everywhere. Great improvements are also possible in the milk-giving capacity of cows. The different breeds in this country are divided between dairy cattle and beef animals. To supply our national requirements generally, it appears to be desirable to obtain an animal yielding both a large amount of milk and eventually beef of high quality in reasonable quantity. The Dairy Short Horn appears to be such a double-purpose animal. Mr. Robert Mond has therefore devoted himself to raising a pure bred Dairy Short Horn Herd; by using bulls with long pedigrees of high milk yield in their female ancestors he has succeeded in greatly increasing the average milk yield and has now arrived at having the highest milk yield throughout the country.

Our Proper Economic Policy.

The public should be made fully aware of its dietetic backslidings. Some elementary understanding of the principles of sound scientific dietetics must be infused into the medical profession, in place of the rank empiricism which now counts for knowledge. Even politicians need to be informed.

Not so long ago the cry was that we were degenerates. On inquiry no justification of the outcry was found but it was clear that the masses were vastly under-nourished. The war has shown that physical degeneracy is the least of our failings but the scientific inquiries of recent years, to which I have referred, justify the conclusion that the masses are being fed on wrong lines, not merely insufficiently.

Our economic policy will certainly need most careful revision in the light of our growing knowledge of dietetic requirements. We must turn our attention far more, indeed as far as possible, to the production of fresh foods and when using preserved foods must take care to supplement the ration with uncooked foods or other materials, such as yeast, which afford the necessary advitants. Our chief care should be the recovery of milk—clean, undiluted, unsterilised and of far higher average quality than is commonly purveyed.

Allotment gardening, which has received such an impetus during the war, has been advocated chiefly on the grounds of increasing the food supply. But it will be obvious that its importance is to be sought far more in the fact that it is a means of adding largely to the supply of fresh food and that the production of salads which can be eaten uncooked is of particular consequence, as cooking serves to destroy a very large proportion of the antiscorbutic advitant present in vegetables. The early production of cucumbers and tomatoes is to be commended, not discouraged, as it was officially a year or so ago, as these come on the market at times when fresh salads are difficult to procure; but such

raw foods are specially valuable at all times, particularly in the absence of fruit.

It has been too much our habit to regard fruit as a luxury; in reality it is a necessary to life and should be used as regularly as any ordinary article of food, as far as possible raw. The habit of eating fruit with the first meal of the day, as in France and the United States of America or after dinner as dessert, is entirely rational.

To obtain the increased supply of milk we need we must resort to methods of cultivation far more intensive than those adopted hitherto. The same may be said of meat. In the case of vegetables improvement of the methods of supply is probably the most necessary step to be taken. Fruit cultivation should also be greatly encouraged. If, having done all we can to produce the fresh food we must have, we can also increase our wheat supply, well and good: but taking into account that—apart from the germ—this is very largely of value only as a fuel food and that it can be stored without particular difficulty or detriment to its food value, we may be content to draw our main supply from regions where it can be grown with greater economic advantage.

We shall need free and wide discussion of all these matters and inquiries must be opened in many directions—not confined to any official body or institution. It is only necessary to turn to the report recently issued by the Royal Society Food (War) Committee to see how easy it is to treat the subject too narrowly—from some one point of view—and how dangerous it would be to establish any such organisation permanently, even for the purposes of research. The report reeks of calories—we are treated too much as though we were mere energy consuming machines; advitants are referred to but dismissed in half a folio page and their dominant importance is in no way accentuated. This has been the official blunder of the Food Ministry throughout the war: it is only because of our public common sense that the nation has escaped with so little injury; probably also we were much helped by the large use made of potatoes.

That normal development can only take place if all the constructive elements be supplied in due proportion there can be no doubt; it is on this account that a varied dietary is of such importance. From this point also a large proportion of protein food seems to be desirable —as this is the main source of the constructive units—particularly in the case of children. Pigs it is known cannot be fattened on maize alone. The disease pellagra has often been ascribed to the use of maize as cereal food. As tryptophane is absent from maize, in view of the proof furnished by Hopkins' experiments that tryptophane is an essential food unit, such observations are of considerable significance.

That sterility may be a consequence of faulty feeding is more than probable. The modern inability of women to meet the claims of maternity is in no slight degree often conditioned by malnutrition: they are only too apt to be careless feeders and, in their unselfishness, to put up with anything; full of fancies, many not only eat far too little but do not vary their diet sufficiently and even avoid the articles which are most necessary.

The disparagement of meat by the physiologists during the war, however expedient on economic grounds, cannot well be justified on grounds of principle. The same argument applies to the non-recognition of brain workers as having any special nitrogenous requirements. The nervous mechanism is altogether peculiar in structure and it may well be that, to keep it in repair, the organism has need not only of a wide choice of materials but of a considerable quantity of particular foods, in order that it may obtain the necessary minimum of constituents present only in minimal amount. Even on the ground of digestibility, a meat diet seems to be specially valuable: as the cleavage products are rapidly deaminated in the liver and compounds are passed into circulation which not only cannot be reassimilated but are oxidisable with special ease. The unfortunate tendency to regard our food practically as fuel has led to very narrow views being taken on the subject generally.

In the coming years our chief care should be the health of the rising generation, from earliest infancy onwards. The value of physical exercise, the need of giving instruction in the problems of sex, the importance of better homes, the evils of drink, have been constantly impressed on the public notice—but the attention paid to food has been almost nil; yet it is clear that the "mens sana in corpore sano" will not be achieved unless this be made the subject of primary importance. In the light of Colonel McCarrison's inquiry, it is permissible to conclude that juvenile sensitiveness to infectious disease is in no slight degree an outcome of faulty nutrition and that if rationally fed at all times children would be

far less sensitive to attack. The subject is one which concerns our boarding schools in particular.

Children should always have a varied diet. The chief difficulty will be to provide an adequate amount of the fat-soluble antirachitic factor, owing to the shortage and cost of butter, milk and eggs; clarified beef fat or suet is almost the only effective fatty substitute available; from this point of view, suet puddings are to be advocated but they should be made with germ-flour if possible. Germless white wheaten flour and rice, be it remembered, are only of basal value, almost entirely as fuels, not as nourishing foods.

It is much to be hoped that fish oils will be made edible and largely used. It should be noted that the antirachitic advitant is present in fair proportion in various fresh vegetables—cabbage, raw carrots, lettuce and even dried spinach, to a less extent in potatoes.

The water-soluble antineuritic factor is generally present in fair proportion in many foods, in wheat-germ, peas and beans but to a minor extent in vegetables; yeast is particularly rich in this factor.

The antiscorbutic factor is to be found in fresh vegetables and fruits. As it is very easily destroyed by heating, the use whenever possible of these foods uncooked is to be recommended.

In concluding this altogether inadequate discussion of a subject of supreme public importance, I would urge that we must set in the forefront of our economic policy the proper education of the medical man and see to it that this be given a sure scientific foundation: no adequate effort has been made hitherto by the schools to ensure training in scientific method from the outset.

BRITISH ASSOCIATION.

Presidential Address.

(*Continued from page* 680.)

Aircraft.—It may be justly said that the development in aircraft design and manufacture is one of the astonishing engineering feats of the war. In August, 1914, the British Air Services possessed a total of 272 machines, whereas in October, 1918, just prior to the Armistice, the Royal Air Force possessed over 22,000 effective machines. During the first twelve months of the war the average monthly delivery of aeroplanes to our Flying Service was fifty, while during the last twelve months of the war the average deliveries were 2,700 per month. So far as aero-engines are concerned, our position in 1914 was by no means satisfactory. We depended for a large proportion of our supplies on other countries. In the Aerial Derby of 1913, of the eleven machines that started, not one had a British engine. By the end of the war, however, British aero-engines had gained the foremost place in design and manufacture, and were well up to requirements as regards supply. The total horse-power produced in the last twelve months of the war approximated to eight millions of brake horse-power, a figure quite comparable with the total horse-power of the marine engine output of the country.*

Much might be written on the progress in aircraft, but the subject will be treated at length in the sectional papers. In view of the recent trans-Atlantic flights, however, I feel that it may be opportune to make the following observations on the comparative utility of aeroplanes and airships for commercial purposes. In the case of the aeroplane, the weight per horse-power increases with the size, other things being equal. This increase, however, is met to some extent by a multiplicity of engines, though in the fusilage the increase remains.

On the other hand, with the airship the advantage increases with the size, as in all ships. The tractive effort per ton of displacement diminishes in inverse proportion to the dimensions, other things, including the speed, being the same. Thus, an airship of 750 ft. length and 60 tons displacement may require a tractive force of 5 per cent., or 3 tons, at 60 miles per hour; and one of 1,500 ft. in length and $8 \times 60 = 480$ tons displacement would only require $2\frac{1}{2}$ per cent. $\times 480 = 12$ tons at the same speed, and would carry fuel for double the distance.

With the same proportion of weight of hull to displacement, the larger airship would stand double the wind pressure, and would weather storms of greater violence and hailstones of greater size. It would be more durable, the proportional upkeep would be less, and the proportional loss of gas considerably less. In other words, it would lose a less proportion of its buoyancy per day. It is a development in which success depends upon the project being well thought out and the job being thoroughly well done. The equipment of the airsheds with numerous electric haulage winches, and all other appliances to make egress and ingress to the sheds safe from danger and accident, must be ample and efficient.

The airship appears to have a great future for special commerce where time is a dominant factor and the demand is sufficient to justify a large airship. It has also a great field in the opening up of new countries where other means of communication are difficult. The only limitation to size will be the cost of the airship and its sheds, just as in steam vessels it is the cost of the vessels and the cost of deepening the harbours that limit the size of Atlantic liners.

* See Lord Weir's paper read at the Victory Meeting of the North-East Coast Institution of Engineers and Shipbuilders, July, 1919.

Such developments generally take place slowly, otherwise failures occur—as in the case of the "Great Eastern"—and it may be may be many years before the airship is increased from the present maximum of 750 ft. to 1,500 ft. with success, but it will assuredly come. If, however, the development is subsidised or assisted by Government, incidental failures may be faced with equanimity and very rapid development accomplished.* In peace time the seaplane, aeroplane, and airship will most certainly have their uses. But, except for special services of high utility, it is questionable whether they will play more than a minor part as compared with the steamship, railway, and motor transport.

[The next subject dealt with by the President was Electricity. As a means of transmitting power over long distances electricity, he pointed out, has no rival.]

Water-power and Coal.—The amount of available water-power in the British Isles is very small as compared with the total in other countries. According to the latest estimates, the total in the British Isles is under 1½ million horse-power, whereas Canada alone possesses over 20 millions, of which over 2 millions have already been harnessed. In the rest of the British Empire there are upwards of 30 millions and in the remainder of the world at least 150 millions, so that England herself possesses less than 1 per cent. of the water-power of the world. Further, it has been estimated that she only possesses 2½ per cent. of the whole coal of the world. To this question I would wish to direct our attention for a few minutes.

I have said that England owes her modern greatness to the early development of her coal. Upon it she must continue to depend almost exclusively for her heat and source of power, including that required for propelling her vast mercantile marine. Nevertheless, she is using up her resources in coal much more rapidly than most other countries are consuming theirs, and long before any near approach to exhaustion is reached her richer seams will have become impoverished, and the cost of mining so much increased that, given cheap transport, it might pay her better to import coal from rich fields of almost limitless extent belonging to foreign countries, and workable at a much lower cost than her own.

Let us endeavour to arrive at some approximate estimate of the economic value of the principal sources of power. The present average value of the royalties on coal in England is about 6*d.* per ton, but to this must be added the profit derived from mining operations after paying royalties and providing for interest on the capital expended and for its redemption as wasting capital. After consultation with several leading experts in these matters, I have come to the conclusion that about 1*s.* per ton represents the pre-war market value of coal in the seams in England.

* The literature on this subject includes an article which appeared in *Engineering* on January 3rd, 1919.

It must, however, be remembered that, in addition, coal has a considerable value as a national asset, for on it depends the prosperity of the great industrial interests of the country, which contribute a large portion of the wealth and revenue. From this point of view the present value of unmined coal seems not to have been sufficiently appreciated in the past, and in the future it should be better appraised at its true value to the nation.

This question may be viewed from another aspect by making a comparison of the cost of producing a given amount of electrical power from coal and from water-power. Assuming that one horse-power of electrical energy maintained for one year had a pre-war value of £5, and that it requires about eight tons of average coal to produce it, we arrive at the price of 6*s.* 3*d.* per ton—*i.e.* crediting the coal with half the cost. The capital required to mine eight tons of coal a year in England is difficult to estimate, but it may be taken approximately to be £5, and the capital for plant and machinery to convert it into electricity at £10, making a total of £15. In the case of water-power, the average capital cost on the above basis is £40, including water rights (though in exceptionally favoured districts much lower costs are recorded).

From these figures it appears that the average capital required to produce electrical power from coal is less than half the amount that is required in the case of water-power. The running costs, however, in connection with water-power are much less than those in respect of coal. Another interesting consideration is that the cost of harnessing all the water-power of the world would be about 8,000 millions, or equal to the cost of the war to England.

Dowling has estimated the total coal of the world as over seven million million tons, and whether we appraise it at 1*s.* or more per ton its present and prospective value is prodigious. For instance, at 6*s.* 3*d.* per ton it amounts to nearly one hundred times the cost of the war to all the belligerents.

In some foreign countries the capital costs of mining are far below the figures I have taken, and, as coal is transportable long distances and, generally speaking, electricity is not so at present, therefore it seems probable that capital will in the immediate future flow in increasing quantity to mining operations in foreign countries rather than to the development of, at any rate the more difficult and costly, water-power schemes. When, however, capital becomes more plentiful the lower running costs of water-power will prevail, with the result that water-power will then be rapidly developed.

[In discussing further the possible new sources of power, the President suggested that some attempt should be made to sink a shaft as deep as may be found practicable and at some locality selected by geologists as the most likely to afford useful information.]

Research.—The whole question of the future resources of the Empire is, I venture to think, one which demands the serious attention of all scientists. It should be attacked in a comprehensive manner, and with that insistence which has been so notable in connection with the efforts of British investigators in the past. In such a task, some people might suggest, we need encouragement and assistance from the Government of the country. Surely we have it. As many here know, a great experimental step towards the practical realisation of Solomon's House as prefigured by Lord Bacon in the "New Atlantis" is being made by the Government at the present time. The inception, constitution, and methods of procedure of the Department, which was constituted in 1915, were fully described by Sir Frank Heath in his paper to the Royal Society of Arts last February, and it was there stated by Lord Crewe that, so far as he knew, this was the only country in which a Government Department of Research existed.*

It is obvious that the work of a Department of this kind must be one of gradual development with small beginnings, in order that it may be sound and lasting. The work commenced by assisting a number of researches conducted by scientific and professional societies which were languishing as a result of the war, and grants were also made to the National Physical Laboratory and to the Central School of Pottery at Stoke-on-Trent. The grants for investigation and research for the year 1916–17 totalled £11,055, and for the present year are anticipated to be £93,570. The total income of the National Physical Laboratory in 1913–14 was £43,713, and owing to the great enlargement of the Laboratory the total estimate of the Research Department for this service during the current year is £154,650.

Another important part of the work of the Department has been to foster and to aid financially associations of the trades for the purpose of research. Nine of these associations are already at work; eight more are approved, and will probably be at work within the next two months; and another twelve are in the earlier stage of formation. There are also signs of great increase of research by individual factories. Whether this is due to the indirect influence of the Research Department or to a change in public opinion and a more general recognition of the importance of scientific industrial research it is difficult to say.

The possibility of the uncontrolled use on the part of a nation of the power which Science has placed within its reach is so great a menace to civilisation* that the ardent wish of all reasonable people is to possess some radical means of prevention through the establishment of some form of wide and powerful control. Has not Science forged the remedy, by making the world a smaller arena for the activities of civilisation, by reducing distance in terms of time? Alliances and unions, which have successfully controlled and stimulated republics of heterogeneous races during the last century, will therefore have become possible on a wider and grander scale, thus uniting all civilised nations in a great League to maintain order, security, and freedom for every individual, and for every State and nation liberty to devote their energies to the controlling of the great forces of Nature for the use and convenience of man, instead of applying them to the killing of each other.

Many of us remember the President's Banner at the Manchester Meeting in 1915, where Science is allegorically represented by a sorrowful figure covering her eyes from the sight of the guns in the foreground. This year Science is represented in her more joyful mien, encouraging the arts and industries. It is to be sincerely hoped that the future will justify our present optimism.

* The Italian Government are now establishing a National Council for Research, and a Bill is before the French Chamber for the establishment of a National Office of Scientific, Industrial, and Agricultural Research and Inventions.

* For instance, it might some day be discovered how to liberate instantaneously the energy in radium, and radium contains 2½ million times the energy of the same weight of T.N.T.

GENERAL NOTES.

Reinforced Concrete Ship.—A reinforced concrete vessel, the "Faith," has arrived from the United States and is in dock on the Thames. She is 336 ft. long and 46 ft. wide, her greatest depth being some 25 ft., with an average draught of about 22 ft. The tonnage is 3,070. Normally she is worked by electricity. She accomplished the passage in nineteen days, travelling at the rate of 7½ knots, but it is claimed that she can attain a speed of 10 knots. When tracked by an 80-mile gale, it is reported she only listed some twelve degrees, and in a 60-mile wind not more than two degrees. A boat of this class of 8,000 tons has been launched in New York and will, it is said, shortly cross the Atlantic.

The Society of Engineers.—In compliance with a suggestion by the Ministry of Labour (Appointments Department), the library and reading-room of the Society of Engineers (Incorporated, 17, Victoria Street, Westminster, S.W.(1), have been placed at the disposal of officers at present looking out for appointments in the engineering and allied professions. All such officers are also invited to attend the ordinary meetings of the Society; particulars of which may be obtained on application to the Secretary.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—September 19, 1919.

No. 3488. SEPTEMBER 26, 1919. Vol. LXVII

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON :
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,488. VOL. LXVII.

FRIDAY, SEPTEMBER 26, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

INDIAN SECTION.

The Indian Section Committee, as appointed by the Council, is as follows :—

Sir Henry Trueman Wood, M.A. (Chairman of the Council).
Sir William Duke, G.C.I.E., K.C.S.I. (Chairman of the Committee).
Lord Ampthill, G.C.S.I., G.C.I.E.
Sir Charles H. Armstrong.
Sir Arundel T. Arundel, K.C.S.I.
Sir J. Athelstane Baines, C.S.I.
Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.
Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.
Lieut.-Colonel Sir Charles H. Bedford, LL.D., D.Sc., M.D.
Thomas Jewell Bennett, C.I.E., M.P.
Sir M. M. Bhownaggree, K.C.I.E.
Lord Carmichael, G.C.S.I., G.C.I.E., K.C.M.G.
David T. Chadwick, I.C.S.
Sir Valentine Chirol.
Sir William Henry Clark, K.C.S.I., C.M.G.
Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.
William Coldstream, B.A.
Laurence Currie, M.A., J.P.
Earl Curzon of Kedleston, P.C., K.G., G.C.S.I., G.C.I.E.
Right Hon. Sir Henry Mortimer Durand, G.C.M.G., K.C.S.I., K.C.I.E.
James Fairbairn Finlay, C.S.I.
Sir Frederic W. R. Fryer, K.C.S.I.
Colonel Arthur Hills Gleadowe-Newcomen, C.I.E., V.D.
Sir Krishna Govinda Gupta, K.C.S.I.
Colonel Sir Thomas Hungerford Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc.
Sir Philip Perceval Hutchins, K.C.S.I.
Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E.
Lord Islington, P.C., G.C.M.G., D.S.O.
Sir Henry Evan M. James, K.C.I.E., C.S.I.
Louis James Kershaw, C.S.I., C.I.E.
Sir Henry Ledgard.
Sir Frederic S. P. Lely, K.C.I.E., C.S.I.
Major-General Beresford Lovett, C.B., C.S.I.
Sir Charles Campbell McLeod.
Colonel Sir Arthur Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I.
Sir John Ontario Miller, K.C.S.I.
Sir Prabashankar Dalpatram Pattani, K.C.I.E.
Right Hon. Sir Joseph West Ridgeway, G.C.B., G.C.M.G., K.C.S.I.
N. C. Sen, O.B.E.
Colonel Sir Richard Carnac Temple, Bt., C.B., C.I.E.
Carmichael Thomas.
J. A. Voelcker, M.A., Ph.D., F.I.C.
N. N. Wadia, C.I.E.
Sir Frank Warner, K.B.E.
Colonel Charles Edward Yate, C.S.I., C.M.G., M.P.
S. Digby, C.I.E. (Secretary).

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

Wednesday afternoon, February 19th, 1919; SIR WILLIAM BARRETT, F.R.S., in the chair.

The paper read was—

THE USE OF ELECTRICITY IN AGRICULTURE : *

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

Agriculture is almost certainly the oldest human industry, and the stage in its development when animal power was introduced to aid human endeavour is not traceable in recorded history, nor is tradition helpful on the point. We know that the Egyptians employed querns driven by oxen for the grinding of corn, while oxen, asses and horses were employed from very early days for the hauling of ploughs and rollers, and for the transportation of farm produce.

The use of water-power for irrigation and drainage, and the employment, about the opening of the twelfth century, of wind-power for the same purpose, form the first introduction of mechanical power into agriculture, and with the sole exception of its use for driving corn-grinding machinery, this was, for all practical purposes, the extent of its application until the invention of the threshing machine, to which written reference is first found in 1743. The first threshing machines were driven by water-power, though later Boulton and Watt steam engines were employed. There was little further development in the application of mechanical power until the middle of the nineteenth

* Owing to pressure of work Dr. Crowley has hitherto been unable to complete the manuscript of his paper, and publication has been postponed in order to give him time to do so. The second part of the paper will be printed next week.

century, which, to quote the United States Twelfth Census Report, "practically marks the close of the period in which the only farm implements and machinery, other than the wagon, cart and cotton gin, were those which, for want of a better definition, were called implements of hand production."

At this period efforts were made to introduce steam-power into farm work. Steam tractors were devised for the operation of portable farm implements, but without much success. Greater success attended the introduction, about 1855, of the well-known Fowler steam plough, which consisted of haulage gear by which a single portable steam engine of the type used for threshing, stationed at one side of the field to be ploughed, hauled, by means of a steel rope, a large plough from one side of the field to the other.

Modifications were introduced into this system of ploughing, such as, for instance, the "roundabout" system invented by Fisken, who is also responsible for the arrangement by which the haulage gear was automatically moved forward after each set of furrows had been ploughed, but the most definite advance was the introduction, again by Fowler, in 1865, of the two-engine system in which two portable engines were employed, the one to haul the plough in one direction, and the other in the opposite direction, across the field to be ploughed.

Experiments were made in 1893 with tractors fitted with internal-combustion engines for the direct hauling of ploughs and cultivators, but it was not until 1903 that the difficulties met with could be said to have been satisfactorily overcome. A large number of these tractors are in use in America, and conditions created by the war have caused them to be introduced in large numbers into the United Kingdom.

The first application of electricity to farm work to which the writer can trace any reference * was in 1879, when Gramme electric motors were employed in France to replace the steam engines, in the two-engine ploughing system introduced by Fowler. These motors, as in the systems of Fowler and Fisken, operated not only ploughs, but harrows, weeding, sowing machines, etc. This application of electricity, made by Chrétien and Félix, showed considerable enterprise, considering the early stage in the development of electrical engineering at which it was made.

Electricity to-day finds many applications in agriculture, including—

(*a*) The lighting of homesteads, farmyards and buildings.

(*b*) The provision of power through the medium of—

(1) Non-portable motors for the operation of stationary machines as dairy machines, corn-grinding machinery, etc.; of—

(2) Portable motors for the operation of portable machines, such as ploughs, harrows, etc., and of stationary machines which run too intermittently to justify separate motors.

(*c*) The provision of transport facilities either through electrically-operated light railways, tramways, railless traction, or self-propelled electrical vehicles.

(*d*) The production of artificial fertilisers, more particularly through the fixation of atmospheric nitrogen; and

(*e*) The direct application of electricity to growing crops, a subject which is at present being investigated by a special committee.*

It is proposed to confine this paper to the use of electricity for purposes of light and power. It will, however, be borne in mind that the economic provision of electricity for light and power in rural districts may be, and frequently is, almost wholly dependent on the demand created by more concentrated industries. Thus the demand for electricity at a large chemical works, at a point distant from a central station, may necessitate the running of a transmission line which rural demands alone would never justify, while a transmission system for electrical traction can supply the rural area through which it passes with electricity for purposes other than transport.

In recent years the greatest advance in the application of electricity to agriculture has taken place in Germany, in the United States, in Canada, and in Spain. Germany has been far in advance of other countries in this interesting application of electricity, and it was felt that a description of the development there, which the writer had an opportunity of examining immediately prior to the war, might be helpful in encouraging a demand for electricity for farm work, while such a demand should have an important bearing on the development of electricity supply in rural districts.

Introduction.

It is well known that owing to the increasing scarcity of labour, rise in wages, and in the cost of land, and owing also to the increasing

* *La Lumière Électrique*, No. 3, Tome 1er, June 15th, 1879.

* Committee formed by the Conjoint Board of Scientific Societies under the auspices of the Royal Society.

significance of foreign competition in the world's markets, German agriculturists were, in the years prior to the war, employing machinery to a continually increasing extent.

Thus between 1895 and 1907 the number* of steam or motor threshing machines increased from 259,364 to 488,867; of other threshing machines, 596,869 to 947,003; sowing machines, 169,465 to 290,039; mowing machines, 35,084 to 201,325; milk centrifugals, 87,987 to 339,906; steam ploughs, 1,696 to 2,995.

As showing the effect of the introduction of machinery and improved methods into agriculture, it is interesting to note† that whereas "in 1855 four hours and thirty-four minutes' labour was required to produce a bushel of corn, in 1894 the average time was reduced to forty-one minutes."

It is further stated in the Year Book of the United States Department of Agriculture, 1899, that "it formerly required eleven hours of manual labour to cut and cure a ton of hay, whereas the same work is to-day accomplished, with the aid of machinery, in one hour and thirty-nine minutes, the labour cost being reduced from 83⅓ cents to 16⅓ cents per ton."

Power of some kind is necessary for carrying out all work, and for the operation of agricultural machinery mechanical power has to be provided where human and animal power are not employed.

Manual labour offers the dearest and least continuous source of power, particularly at the present day, when, owing to the competition of other industries, labour in agricultural districts is becoming every day more scarce and dear. By preference, for agriculture, animals are used as a source of power; but when compared with sources of mechanical power they have this disadvantage, amongst others, that they as well as human beings do not work at a uniform rate, while their support during the necessary periods of rest, or of enforced idleness due to illness, involves considerable expense.

Mechanical power also enables work to be done that could not otherwise be handled, while the greater power available and the higher speeds enable more work to be done in a given time and at less cost than is possible with animal labour. It should also be borne in mind that the elimination of animal power from farm work would enable millions of acres at present devoted to the raising of food for fodder to be devoted to more productive purposes. It is estimated that only from 6 to 10 per cent. of the heat value of the food consumed by animals is returned as work, while, from records made by the United States Government, it would appear that on the average a farm horse does not work more than three hours per day, the pre-war cost of his labour being estimated at 8 to 13 cents per hour. This figure would, of course, be very much higher to-day owing to the great increase not only in the first cost, but in the up-keep of the animals. In comparing this figure with costs of mechanical power, it should be remembered that the figure taken by James Watt as the power of an average horse, viz., 33,000 foot lb. per minute, is on the high side, probably intentionally so. The average horse works at the rate of approximately two-thirds of one brake horse-power.

As sources of electrical power the farmer has at his disposal wind, water and heat. The wind can be utilised by means of windmills, and is used in many cases, particularly for purposes of irrigation or drainage, but on account of its uncertainty and the low powers generally available it need not be seriously considered for agricultural purposes. Water-power is of considerably more importance in connection with farm work, and might be used to a far greater extent than at present in this country. It is worthy of note that one firm alone installed* in North Wales between 1907 and 1917 not less than 234 water-power installations for farm power and lighting, varying in horse-power from a maximum of 9 h.p. to a minimum of 1 h.p. This important development in the use of water-power for small farms in this area can be taken as an indication that its value was realised by the farmers.

For the production of power from heat the farmer can choose between engines using coal, peat, oil, and, in some isolated instances, gas. It was early realised in Germany that mechanical power developed from any of the sources to which reference has been made was, in general, only available at the particular place of generation and in the immediate neighbourhood, as the transmission of mechanical power to any distance by mechanical means is not a practical proposition.

Portable steam engines have, of course, been in use a great many years for the driving of threshing machines, etc., and portable oil

* Report to Board of Agriculture and Fisheries, by J. H. Cahill, 1913.

† "Electricity on the Farm," 1913, General Electric Company, New York.

* See *Electrical Review*, Vol. 83, No. 2127, August 30th 1918.

engines have recently been introduced on a limited scale for farm work. The fact that these engines are portable, however, limits their weight, and since heat engines have a high weight per h.p. this limits the power that can be developed by them.

Since it is particularly characteristic of agricultural work that a considerable proportion of it has to be carried on, not necessarily close to any particular source of power, but over a more or less wide area, farm conditions could only be met, so far as power is concerned, by the use of the portable engines above referred to, and, as we have seen, their power is limited by the weight it is possible to transport over soft agricultural ground, and their use by the fact that fuel and in most cases water have to be brought to them.

It was these limitations that led to the development in the use of electricity which has been so notable a feature of agricultural work in Germany of recent years. In many large farms the farmer generates by means of one or other of the sources of power referred to the electricity he needs for his farm work. By far the greater amount of power, however, used electrically on farms in Germany is distributed from central stations.

It was early realised that power generated in a central station was considerably cheaper than power generated in a small private plant, because the centralisation of the power plant resulted in a saving in wages, maintenance, and running costs, etc., and rendered it possible to employ large generating units which were much more efficient, while since a large number of different consumers take their power from the same central station, the maximum demands of each consumer for power would not occur at the same time, and therefore smaller plant could be installed to meet these various demands than would be necessary if each separate consumer had to instal his own plant. In general it may be said that the more varied and numerous are the demands for power in any district, the better is the case for the generation of that power in a central station. It is also worthy of note that every large consumer who takes his power from a central station, particularly if his load factor is good, as is particularly the case with chemical works, enables the cost of power to all the other consumers on that station to be reduced.

Owing to their comparative unimportance no attention has been given in this paper to the distribution of power for agricultural purposes by means of gas, air, steam, etc., by water or by shafting, belts, ropes, etc. Where electricity is generated on the farm itself it has to be distributed by means of a low-tension electrical transmission system to the various points on the farm where it is required, or, in exceptional cases, where the farm is particularly large, by means of a high-tension transmission system to certain points, low-tension mains being used for local distribution from these points.

Where electricity is distributed from a long distance central station the electricity is transmitted by high-tension transmission lines to various points, and usually by transmission mains of medium tension to the various farms, and from these medium tension mains current is taken for use on the farm where required in a manner which will be described later.

The use of electric current for light and power made little progress among farmers in Germany until the advantages associated with it became fully known. As has not infrequently been the case in connection with electrical developments, the first use of electricity for farm work was for lighting, and it was the addition of small motors to lighting installations that first popularised the employment of electricity for power purposes. The mistrust of the farmer had almost completely disappeared before the war, and the cheap production of electric power in central stations, and its transmission by carefully designed transmission systems in the various parts of the country, coupled with the great increase in the number of these stations, now give the German farmer an opportunity of advantageously introducing electricity into his farmyard and field, for lighting his buildings, and driving his various machines, thus enabling him to do his farm work in a more favourable manner, and rendering him more independent of daylight and weather conditions.

This development has been encouraged by the increasing scarcity of labour and its increasing cost, as well as the increase in first cost and maintenance of haulage animals, all of which had been making it more difficult for the German farmer to secure a satisfactory return on his outlay.

The development of electricity enables the farmer to do as much of his work as possible independently of human labour, and by the great development in the design of motors technically suitable for agricultural purposes, the charges for attendance cost have been

reduced, and the portability of the machines greatly increased.

In general, it may be said that the introduction of electric driving into German agriculture has meant a reduction in the total working power required on the farm, has enabled the farmer to use his agricultural machines for a longer period, effect a reduction in the number of workers employed, and secure the production of farm produce in a better manner than before.

Electric Lighting.

Electricity for lighting purposes may be produced in a private plant on the farm, or may be taken from a central station. In the former case direct-current is frequently used, while 3-phase current is almost invariably distributed from central stations. The following remarks regarding lighting installations apply equally in both cases.

Where electric lighting is employed in agricultural work in Germany the incandescent lamp is generally preferred. It may, in fact, be said that before the war there had been a great decline in the use, and consequently in the manufacture, of arc-lamps of all types in Germany, with a corresponding increase in the manufacture of incandescent lamps.

For agricultural purposes many advantages were claimed for the incandescent electric lamp. The light being produced by the glow of a carbon or metal filament in a vacuum within a glass bulb, there is an entire absence of combustion and of flame such as would be incidental to matches, tinder boxes, oil, gas, etc. There is, therefore, no danger from fire, particularly since on the breakage of the glass bulb the filament is immediately destroyed, and the destruction of the filament interrupts the electric current.

Electric lamps should not, however, be placed in contact with very inflammable material, because, under certain circumstances, the cooling of the bulb by air currents may be interfered with, and the inflammable material set on fire.

The great security against fire with incandescent electric lamps and the powerful lights that can be installed enable the farmer to carry on work in the farm buildings during the dark hours that would not be possible with other lighting systems. Work can be carried out during the morning and evening hours of the autumn, winter and spring in barns, forage lofts, and similar places where danger of fire ordinarily exists.

Owing to the absence of actual combustion oxygen is not abstracted from the air by the incandescent lamp, and living rooms are not contaminated by the production of impure gases.

The lamps are convenient to instal, and may be placed in any position to suit the lighting effect required, while the lights can be put on or off instantly by the closing or opening of a switch.

Control switches may be placed at an easily accessible point, and generally without reference to the position of the lamps, controlling them singly or in clusters as may be desired. Switches may, for instance, be fixed outside a stable to control the interior lighting, and enable the stable to be examined before entry, or a switch can be installed at one end of a shed by which the shed can be lit up on entry, a further switch at the other end serving to extinguish the lights on leaving.

A species of control much appreciated by farmers, and only possible with electric lighting, is the control of large farmyard lights by an auxiliary switch in the farmer's bedroom, which enables the yard to be conveniently lighted up should a suspicious noise be heard during the night.

The introduction of the metal filament lamp, which only consumes for a given candle-power about one-third of the electricity taken by the carbon filament, renders electric lighting one of the cheapest, if not the cheapest form of lighting.

The half-watt lamp, which gives a light of a colour resembling daylight, and consumes still less current than the metallic filament lamp, but which is at present available only in the larger sizes, enables further economies to be effected, and in the larger powers is much used for outside lighting.

For farm work the following sizes of lamp are generally recommended :—

	Candle-power of Lamps.
For living rooms . . .	16 to 25
For bedrooms, engines, cattle-sheds and passages	16
For barns and hay-lofts .	32
For visitors' rooms, yard lighting and road lighting	32, 50 and more.

Lamps in living rooms, bedrooms, and business offices are usually provided with reflectors of glass, metal or other suitable material for the sake of appearance, and to enhance the lighting effect. In the open air and in working places, such as cattle-sheds, barns, etc., lamps are usually protected by being enclosed in

strong glass covers to prevent damage to the holders and lamps from moisture, gases, etc., and where mechanical damage is possible metallic protecting guards are also provided. For installations inside buildings, insulated copper wires are usually employed, which are laid direct on porcelain insulators in cattle-sheds of sufficient height to avoid direct damage, in conduit on any of the well-known patent steel tube systems, or in ordinary steel conduit.

When it is important to lay the wires inconspicuously, as for the lighting of living rooms, insulated wires covered with a special metallic coating, as in the well-known Kuhlo system, are frequently found. The whole lighting system is, as is usual in such cases, protected from unsafe overloading by the provision of suitable fuses. Fuses of the cartridge type, the special feature of which is the uninterchangeable character of the cartridge which prevents cartridges of larger size than is desirable being used on a given circuit, thus rendering the protection imaginary, are much more common in Germany than in this country.

Special attention also is given in Germany to the design and manufacture of lighting accessories, such as fittings, fuses, switches, etc., to meet agricultural conditions, and it is interesting to note that similar attention has now been devoted in America to the same question, special catalogues being issued by the larger firms.

It is generally urged against electric lighting, and equally also against gas lighting, by farmers that the lamps are not in independent units, as is the case with paraffin lamps and with candles, but have to be connected by wires to an electric circuit. This is undoubtedly a drawback in some cases, but it has the advantage that since the lamps require no attention, they may be placed in almost inaccessible places and switched on and off from accessible positions. The difficulty is also, to a large extent, overcome by the provision of portable and temporary lamps which can be connected by means of a flexible cable and plug to a suitably placed wall socket. These lamps may be used in any place provided a wall socket connected to the terminal wiring is available in the neighbourhood.

Portable hand lamps give excellent service to the farmer when repairing wagons or farm implements, or in the stalls, stables, etc., should animals fall ill. Temporary lights carried on suitable supports are also frequently attached to the portable transformer and motor wagons described later.

It may be of interest to note that the average cost of a number of lighting installations on farms put down by one of the largest German companies varied from 14 to 20 marks per point for lamps with simple switches and without electrolier, and from 16 to 23 marks with suitable electrolier for dry living rooms, halls, etc., while the cost per lighting point in cattle-sheds, outhouses, or the open air with waterproof electroliers, was from 21 to 28 marks.

A common figure to take in Germany for working purposes for the cost of electricity for lighting in rural districts before the war was 40 pfgs. per unit. Metallic filament lamps were taken at 2 marks each, and when working out comparisons with oil or candle lighting the life of incandescent lamps was taken at 1,000 hours, and thus ·2 pfg. per hour added to the cost of current for lighting covered interest and depreciation on the lamp.

Lighting by candle was considered to be the most expensive form of lighting, and was taken at 1½ pfgs. per candle-power hour. Lighting by petroleum lamp was considered essentially cheaper and better, and was assumed to cost 0·11 pfg. per candle-power hour with a 20 candle-power lamp, and petroleum at 20 pfgs. per litre.

With electricity at 40 pfgs. a unit, a 16 candle-power carbon filament lamp cost 2 pfgs. for one hour, while a metallic filament lamp of the same candle-power only cost ⅘ pfg., other candle-powers in both cases being *pro rata.*

It will be seen on the basis of the figures taken that for equal lighting effect carbon filament lamps are more expensive than paraffin lamps, while metallic filament lamps are much cheaper. Generally speaking, and still assuming the cost of current and petroleum mentioned above, for equal candle-power the running cost of the metallic filament electric lamp is less than half that of the paraffin lamp, and this is additional to the advantages they possess as regards cleanliness, security against fire, continual readiness for use, and illumination better distributed over the work to be done.

The following figures for lighting provided by the proprietors of a few German firms may be of interest. In the case of a farm of about 92 acres, eleven incandescent lamps were installed in the dwelling-house and eleven in the working places, and the cost of the lighting plant, apart from the power plant, was 390 marks, and the current consumption during one year for lighting was 177 kw. hours at 40 pfgs. = M 70.80.

In the case of another farm of 60 acres,

nineteen incandescent lamps were installed in the dwelling-house, stalls, barns, lofts and cellars. No figures are given for the cost of the lighting installation, but the current consumption during twelve months for lighting was 102 kw. hours at 40 pfgs. = M. 40.70.

(*To be continued.*)

COFFEE CULTIVATION AND PREPARATION IN CENTRAL AMERICA.

Coffee grows throughout Central America at altitudes ranging from 500 to 5,000 ft., but the largest quantity comes from districts where the elevation runs from 2,500 to 4,000 ft. Most of such lands are found on the western slopes of the central range of mountains. Clay, sand and humus are the soil elements needed.

From an interesting report written by the United States Trade Commissioner, W. M. Strachan, it appears that the coffee plant is put through two stages of cultivation before being set out in permanent positions. The seed is first planted in seed-beds, which are laid out in plots two yards wide, raised a few inches above the level of the surrounding soil. In these plots rows are laid out 8 in. apart, and the seed planted at a depth of 1 in. spaced 9 in. apart. The whole seed-bed is covered with leaves and sprinkled twice daily. When the plant emerges from the ground the seed is intact, but soon splits and two leaves appear. At this stage the plants are removed and placed in a nursery, which is also shaded. At the beginning of the following rainy season the young trees are set out in their permanent positions. At elevations below 3,000 ft. the trees are planted from 3 to 4 varas (vara = 33 in.) apart; above 3,000 ft. they are spaced 4 varas or more.

Transplanting requires great skill, for care must be exercised to avoid a doubling of the principal root. Two methods of transplanting are common, the "piloneade" and the "café en escoba." The first consists in removing the plant from the nursery with a surrounding layer of earth pressed close to the roots, and is the more common practice on the lower lands. At the higher elevations the plants are often removed without preserving any of the soil to which the small fibrous roots cling, and the secondary roots are themselves cut away and the branches trimmed down. The plant is then placed in its permanent position and the soil pressed lightly around the stalk. In high, cloudy regions it is possible to propagate with cuttings from a mature tree. The trees that result from such "estacas" produce earlier, but do not last so long.

On well cared for "fincas" it is customary to prune the trees every spring. The annual pruning has for its immediate object the cutting out of dry branches. Every four or five years a heavier pruning, called "poda baja," is resorted to. Two or three of the large branches are removed with a saw to give entrance to light and to ease the burden of the plant. When the tree grows so high that picking becomes difficult the trunk is severed a few inches above the ground, and new branches grow out from the stump. The oldest coffee trees of Nicaragua were planted sixty years ago, and are still bearing.

Coffee requires a varying amount of shade, according to the elevation at which it is raised. At the highest elevations very little shade is required; at the lowest a dense shade is necessary. The trees used for this purpose are of many different kinds. In some districts, particularly on the east slope of the mountains in Costa Rica, where the rainfall is continuous throughout the year, a shade is provided by plantains and bananas. In the "Pueblos" district of Nicaragua the "madre de cacao" is preferred, but one sees rubber trees, willows, and the whole range of the natural shade trees of the locality.

The cultivation of coffee is simple. Earth is drawn up toward the tree so that the rainfall is drained off the rows. To prevent the washing away of the hillsides, rectangular pits are dug at intervals which collect the surplus flow of water causing it to seep slowly through the soil. Ploughing is not desirable. Weeds are cleaned out twice a year with machetes.

The trees blossom at the end of the dry season. The cherries ripen at the close of the rainy season. All the cherries on any one plant do not ripen at the same time. Where a sufficient supply of labour is available only the ripe cherries are removed at the first picking and the rest are left to mature, but when there is a shortage of labour all approaching ripeness are removed at a single picking. The few that remain are permitted to ripen and fall to the ground, to be picked up by the poor people and cleaned for their own use.

Coffee is quite generally picked by women and girls, who receive a fixed sum per measure. The pickers carry a basket fastened to the waist, leaving both hands free. Where the task system is employed, planters complain that the pickers are apt to injure the trees through careless handling. The baskets are emptied into measures, the measures into carts, and the fruit hauled to the "beneficio," a building fitted out with machinery for removing the pulp and shell.

Coffee-treating machinery is expensive and beyond the reach of the smaller growers, who find it more practicable to sell the fruit in the cherry to the larger finqueros. The beneficio capacity in most localities is considerably greater than the crop, this condition assuring the smaller growers active competition. The motive power of a beneficio is water-power or steam. In Salvador and Nicaragua there are few good streams in the coffee country. Water is needed for washing and fermenting coffee and watering animals, as well as

for motive power. Many finqueros have constructed large, open cement cisterns, which collect water during the rainy season. This shortage of water in certain districts is responsible for the trade classification of coffee as "washed" and "unwashed." The unwashed is dried in the cherry and later cleaned without the aid of water. The product has not so desirable a colour nor so fine a flavour as the washed grade, and fetches a lower price.

The machinery in a beneficio is driven from a central shaft belted either to a steam engine or to a water turbine. A steam engine and boiler is part of the usual equipment of every beneficio, even though a water turbine is used. In the latter case the engine is held in reserve. The shell or husk, removed from the coffee, supplemented by some wood, provides fuel for use under the boilers. Other machines found in the typical beneficio are one or more pulping machines, a set of shellers, a classifier, a centrifugal pump, and a generator for electric lighting. In the busy season the machinery runs day and night. Where water-power is available the generator is geared direct to a separate turbine.

The treatment of the coffee cherry is as follows. Carts loaded with coffee are backed up to a concrete pit, the coffee dumped into measures and then into the pit. From the pit the cherries are elevated with water some 10 ft. in a pipe, which discharges into a trough, depressed at the opposite end. The heavy cherries sink to the bottom and are carried along in the current to a plate. This deflects the main stream with the heavy cherries into the first pulper. The plate in the trough is sunk so that its upper side is just below the surface of the water, creating a ripple, over which the light cherries are carried by the overflow, to drop into a second concrete pit for separate treatment. The pulper is a cylinder revolving at high speed, enclosed with a grated casing and studded with small knobs somewhat like a colander. The cherrries are caught between the casing and these knobs and the outside skin torn away. Several of these machies are placed in series, and so adjusted that the various sizes of cherries are pulped completely. The pulp is discharged at one side and carted to a compost heap, where it lies until thoroughly decomposed, at which stage it makes excellent fertiliser.

The coffee drops from the last pulping machine into a cement-walled pit, where it is permitted to ferment from twenty-four to thirty-six hours. Fermentation disintegrates a mucilaginous substance adhering to the shell, the removal of which facilitates drying and shelling, and improves the colour and quality of the cherry. From this pit the coffee is elevated to and passed through the washer and this substance is completely removed. The washed coffee is then either floated or hauled to the patio at the rear of the beneficio and spread out to dry in the sun. Here it is left for several days, being worked over meanwhile with wooden hoes. It is then shovelled into sacks or two-wheeled rubber-tyred barrows, taken to the beneficio, elevated to the top of the building and dumped into a bin. From the bin it is spouted into the dyer, a large revolving cylinder mounted on hollow axles. Steam from the boiler is piped to an enclosed radiator, around which air forced by a blower is heated, and thence carried by a connecting pipe through the hollow axle into the cylinder. The cylinder is filled with coffee, closed and rotated slowly for twenty-four hours. At the end of this period the parchment surrounding the coffee cherry is thoroughly dried. The dryer is particularly necessary at the beginning of the season, when frequent showers and humidity retard sun-drying. At this stage the coffee is known as "coffee in parchment" (*café en pergamino*). At the end of the twenty-four hours the drying machinery is stopped and the contents allowed to drop on the main floor. Close by is a bucket elevator into which the coffee is shovelled and carried to the top of the building, descending by gravity and passing through a series of screens operated on the principle of a fanning mill. The broken pieces, dirt, and green cherries that passed whole through the pulpers are here removed.

The coffee in parchment passes through the screens and drops through a pipe into the huller, where the parchment is broken off and carried away by a fan blower through a pipe to the fuel bin. The clean coffee is then elevated to a classifier, where it passes through a series of screens which classify it as to width. Some beneficios also use a separate classifier which classifies as to length. Coffee normally is borne in a cherry which contains two seeds flat on one side, but many cherries have a single round seed. Such seeds are removed in the screens and spouted separately. They are known to the trade as "caracol," and are highly esteemed in English markets.

The final step in the beneficio is hand-picking, which has for its object the removal of all black and broken grains. Girls sit at a table having a slightly inclined surface, on which the coffee is spread out in a thin layer. The "culls" (black coffee) is of very inferior grade. Three principal grades of coffee are recognised and known as first, second and third; but as the product of every finca differs slightly from that of every other finca, owing to variations in elevation, atmospheric conditions, soil, etc., each finca uses its own "counter-marks" to identify its own product. For example, a certain beneficio may stencil the word "Aza" on sacks to identify its first quality, "Vera" for its second, and "Chula" for its third.

As the coffee is picked it is brought to the beneficio and measured. The standard for this purpose is the fanega (about 1·4 bushels), an old Spanish measure. The fanega was adopted as a measure of coffee cherries calculated to yield a little more than a quintal of cleared coffee, the excess to go to the beneficio by way of compensation for the cleaning. The excess runs from 5 lb. to 20 lb. of cleaned coffee per fanega. As soon as a load is measured, a dated receipt is issued which may be

cashed in at any time. The undertaking of the buyer is to meet the best price offered by any of his competitors in the district. The price is shaded a little one way or the other, according to the competition or the known quality of the coffee. The price is not subject to much fluctuation; it tends to become fixed in the opening days of the season and to remain constant for the rest of the season. Last season the price was first fixed at 25 colones a fanega, but the increase in value in foreign markets forced the price up to 40 colones, where it remained. When a receipt is surrendered, the price paid is the market price for the day. At the end of the season a statement of account is drawn up.

The operation of a coffee beneficio is an intricate business, requiring a good deal of attention and business acumen. Generally, the owner acts also as manager, but the largest fincas are quite commonly owned by companies which employ a manager. The manager is assisted in the office work by a clerk at a small salary, and a mill foreman. The farm labourers are under the direction of a major-domo, who attends to their feeding and housing in addition to allotting their tasks. Wages are low, and vary considerably in the different countries.

THE INFLUENCE OF THE SIX-HOUR DAY ON INDUSTRIAL EFFICIENCY AND FATIGUE.*

Lord Leverhulme suggests that, instead of the usual eight-hour shift system, in which, as a rule, the machinery is running only forty-four hours a week, the workers should be put on to two six-hour shifts every day, viz., from 7 a.m. to 1.30 p.m., and 1.30 p.m. to 10 p.m., with half-hour breaks for meals. By this means the machinery would be kept running for seventy-two hours per week, and, as the overhead charges for machinery are often higher than the cost of wages, it would still be possible to pay the workers as much for six hours' work as for eight hours' work, even if their rate of production did not improve in consequence of the shorter hours.

The available evidence does not indicate that there would be much improvement of output in many industries. In the tinplate trade the mill-men sometimes work eight-hour shifts, and sometimes six-hour shifts, and their hourly output was found to be only 10 per cent. greater in the latter instance than in the former. In the iron and steel industry a reduction of shift from twelve to eight hours caused no increase of hourly output from blast furnaces and rolling-mills, but 2 to 9 per cent. increase from open-hearth steel furnaces. In the cotton-spinning mills of the United States a reduction of two or three hours in the weekly hours of work caused an almost proportional decrease of output. However, very different results were observed in certain munition industries. Men engaged in the somewhat heavy operation of sizing fuse bodies increased their hourly output 39 per cent. when their nominal hours were reduced from sixty-seven to fifty-six per week, and their actual hours of work from 58·2 per week to 50·6 per week, or their total weekly output went up 21 per cent. Women engaged in turning aluminium fuse bodies on capstan lathes improved their hourly output 56 per cent., and their total weekly output 15 per cent., when their hours of actual work were reduced from 66·0 per week to 48·6 per week. The reason why reduction of hours causes such different effects in different industries is because of the various degrees to which the work is controlled by the personal element, and by machinery. In sizing fuse bodies, the men are not dependent on any machinery whatever, and can speed up to any extent they wish. In turning fuse bodies, the women are to some extent limited by the speed of the machinery. In another operation known as boring top caps, the youths employed fed the caps into semi-automatic machines which could not be speeded up. Consequently their output could only be improved by their keeping more closely to their work, and it was found that when their hours of actual work were reduced from 72·5 per week to 53·1 per week, their hourly output increased only 27 per cent., or was insufficient to balance the reduction of hours, and in consequence their total weekly output fell off 7 per cent.

It is probable that in most industries the eight-hour day does not cause more than a moderate amount of physical fatigue. The workers suffer rather from monotony and boredom, as many of them are engaged on the same task day after day, and year after year. Especially on these grounds it is to be hoped that some such scheme as Lord Leverhulme's will gradually be adopted in the industrial world, but it cannot come suddenly, as it might render us unable to compete in the open markets of the world with other countries which adopted, for instance, two seven-and-a-half-hour shifts per day, instead of two six-hour shifts.

Lord Leverhulme suggests that, in addition to six hours' factory labour, the workers should spend two hours daily in educational and physical training. There is much to be said for this plan.

THE ELECTRICAL TREATMENT OF SEEDS.*

This process is the result of experiments that have been in progress for the last seven or eight years; but it has been tried on a commercial scale for only the last three seasons, and may therefore be called quite new.

* Abstract of a paper read before the Physiological Section of the British Association by H. M. Vernon, M.D.

* Abstract of a paper read before the Agricultural Section of the British Association by Dr. Charles Mercier.

Three seasons ago it was tried by about a dozen farmers; two seasons ago by more than 150, and this season by more than 500. This rapid progress has been due almost entirely to the recommendation made by one farmer to another, or by seedsmen to farmers. The process has not been advertised.

Properly conducted, the electrification of seed never fails to produce an increase in a crop of corn. In every one of the few cases in which this result has not been produced, it has been found that some mistake has been made in the process.

The increase in yield varies from four bushels to twenty or more bushels per acre; the average of a considerable number of trials is about ten bushels, or about 30 per cent.

Every kind of seed requires its own peculiar treatment, and this treatment has been completely ascertained only for cereal crops. Large quantities of electrified root seeds have, however, been sown this season.

The cost of electrification is small; the process is simple, and adds nothing to the labour of the farmer, to the implements for operation on the farm, or to his capital outlay, unless he chooses to electrify the seed for himself. Numerous pairs of specimens grown from electrified and unelectrified seed of the same kind in the same field were shown.

THE VALUE OF LUPINS IN THE CULTIVATION OF POOR, LIGHT LAND.*

Lupins grow with remarkable luxuriance on very light land, poor in lime. At the present time, owing to economic conditions, there is grave danger that considerable areas of this type of land will go out of cultivation. It would appear that an extended growth of lupins offers one of the simplest methods of rendering economically possible the cultivation of this land, and possibly of reclaiming what is already derelict.

Owing to their deep-rooting habit, and their powers of assimilating the free nitrogen of the air, lupins greatly enrich the soil, and whether ploughed in green, folded with sheep, or harvested for seed, leave a considerable quantity of residue upon the ground, which is of great value to the succeeding crop. Very heavy crops of rye are being grown this year after lupins, on land actually adjoining the heath.

When folding, care must be taken not to allow the sheep to eat too much or they will suffer from paralysis owing to lupin poisoning. Suffolk flock-masters fold their sheep on lupins with confidence, and do not regard the risk as serious. Sheep take some time to get accustomed to the bitter flavour of lupins, but thrive remarkably well once they have become used to them. They cannot live satisfactorily on lupins alone, but must have access to other food.

There is often some difficulty in disposing of lupin seed, owing to the fact that it contains some poisonous substance, and is very bitter. In Suffolk lupin grain is fed to sheep at a rate not exceeding half-a-bushel per day per 100 sheep, and the feeding must commence gradually. If too much is fed the sheep become paralysed. It is claimed in Holland that a method has been discovered whereby the poisonous principle can be extracted, and the grain rendered fit for stock-feeding purposes. If this could be done it would give a great stimulus to lupin-growing, and would be a considerable advantage to light-land farmers, as lupins might then occupy the same place on light land as is occupied by beans on heavy land.

* Abstract of a paper read before the Agricultural Section of the British Association by A. W. Oldershaw, M.B.E., B.Sc.

ADVERTISING METHODS IN CHINA.

The population in China is variously computed at from 325,000,000 to 400,000,000, and competent observers have estimated the literacy of the Chinese people to be about 10 per cent. At first glance one is inclined to conclude that there is a large percentage of the whole who cannot be reached through the printed advertisement, but experience has shown that eventually the appeals made in this form of advertising have reached the masses in cases where there was a potential demand and the appeal was strongly put.

According to an interesting report on advertising methods in China sent to the United States Department of Commerce by its Trade Commissioner in China, that country has been, and still is, an unexploited field in many lines of business; and trade has followed the lines of least resistance. The most spectacular advertising campaigns have been made to the masses, and the success of the campaigns for introducing kerosene, cigarettes, and the patent medicine "Jin Tan," are striking illustrations of the efficacy of advertising of this class. In the first case the selling campaign was connected with a real need; in the second it was an appeal to a habit; and in the third to the longing of the physically unfit for health.

On the other hand, these successes must not lead to the conclusion that there is no sale in China for the higher-priced articles. The popular opinion seems to be that China is a country of slow, patient, and industrious, but always poor people. There is, however, a large class of buyers in China who can afford to buy anything they consider necessary to their comfort, as well as many of the luxuries of life.

In China advertising is not organised as it is in Western countries, nor as it is in Japan. The difficulties that the advertiser will meet in starting an advertising campaign are many and annoying to the business man who demands results; nevertheless, a start has been made towards organising on broad and sound lines. The advertising value of the newspaper, poster, calendar, or any other medium, depends entirely upon the class of commodity advertised and the class of buyers it is desired to reach, so the rotation in which the

following list of mediums appear must not be taken as an indication of their relative values in an advertising campaign.

Chinese Press.—There are thousands of newspapers in China, born of temporary needs, political and otherwise, and the early mortality among these papers is large. There are a few that survive the first maladies and have reached a position of comparative financial independence. Their managers have established connections with advertisers, both local and national, which reflect credit on their publications. An agency in Shanghai has a list of about two hundred newspapers published throughout China with which it has established satisfactory business connections. It is reasonably safe to do business with these publications, according to the factors of safety recognised in China; but the widely-known advertiser in Great Britain or the United States will have difficulty in establishing credit with the managers (when he finds out who they are), as the only means the Chinese manager has of learning who is reliable among the foreign firms is by experience, and some of his experiences with foreigners have been most unsatisfactory. The only means of reaching these newspapers, outside of a slow process of building up a reputation with them, is to employ a reputable agency as go-between.

The Chinese newspaper has essentially a class circulation as compared with the popular newspaper in this country. The average circulation of all the more reliable newspapers in China will not exceed three thousand, but this circulation will be in the first instance to a class with a particularly high purchasing capacity. After the first reader finishes with his paper it is passed on to his friends, who often read it aloud to relatives who cannot read. In China there is an almost superstitious reverence for the printed or written word, and a newspaper is often read to shreds. When it is finished as a newspaper it enters on its career as wrapping paper, and the more familiar characters are read by the partly literate.

Hoardings.—In the principal cities, and especially in the Treaty Ports, individuals and companies of English, French, Chinese and Japanese nationality have erected hoardings which are let to advertisers in much the same way as in this country; but there is no way of arranging for an extensive hoarding campaign, as the various companies have not come together in an organisation. There are also concessions for advertising at the railway stations. The concessions on the railway lines running from Mukden in Manchuria to Peking, and from Peking north to Kalgan, are leased to an English advertising agency in Tientsin, and those on all the other Government railways are let to a French company in Shanghai. Boards are erected at each important station, and comprise a valuable addition to the advertising plant in China. A British-American company has erected hundreds of boards throughout China at cross-roads, along canals, and at other points where traffic is heavy, but these are for their own use and are not available to the general advertising public. The Japanese company selling "Jin Tan" has made the most effective use of privately-owned hoardings, and through this medium, and by hanging its advertisements in front of stores where the medicine is sold, and the use of show cards inside, it has made General Jin Tan the best known advertised character in China.

The practice of sniping, or putting posters on dead walls and unauthorised places, is general throughout China, and some of the most successful advertisers have made this practice the hub of their campaigns. Practically every national advertiser uses it to some extent, as it is cheap and effective, especially in conjunction with folder distribution and house-to-house canvassing. The principal drawback is the liability of having the posters destroyed by the village rowdies, but this can often be obviated by an arrangement with the local police or the leader of the rowdies. A cheap paper, partly glazed on one side, was obtainable from Europe before the war, but the higher prices now ruling do not seem to have lessened the use of this form of advertising to any apparent extent.

Chinese Weekly and Monthly Publications.—There are many weekly and monthly Chinese publications, some of which are most effective in reaching certain classes. A woman's magazine published in Shanghai has a considerable circulation among Chinese women, and corresponds to such magazines in America. The same company has five other weekly and monthly publications which go to a class of subscribers of a high purchasing capacity. A study of these periodicals and of the many publications that circulate among other classes of Chinese, will well reward the advertiser who is planning a campaign in China. The missionaries also must not be omitted in considering advertising possibilities, as they have a more than ordinary knowledge of the use and value of Western manufactures.

Use of Postal Facilities.—Department stores and drug companies have made good use of the postal facilities available in presenting their wares to the Chinese. An arrangement can be made with the Chinese Post Office Department for the delivery of a circular or other light advertising matter with each letter. This is generally done by covering small districts, but it has been done in a large way at a surprisingly small cost to the advertiser, and with good results. There are several very large and well-classified mailing lists owned by foreign firms, but only one of these is available to the general advertiser. This has approximately 200,000 names classified by districts or by occupation, and there is one particularly good list that covers a considerable part of the dealers in drugs in China. One feature of the Post Office regulations that is probably peculiar to China, is the custom of delivering postal matter to the house whether the addressee has moved or not. This is not so serious as it would seem, as the

Chinese seldom abandon the place of their birth, and if they do, some one of similar social standing moves in.

Calendars.—The use of calendars is one of the most favoured forms of advertising in China, as the calendar is a most important thing in the life of every Chinese. He regulates his life by the sun, moon, and stars, and never enters upon an important negotiation or journey without a careful consideration of omens and signs. Most advertisers issue a calendar, and some who never advertise in any other way put out the most elaborate designs. They are highly treasured by the recipients, and a regular trade in them is maintained. When the calendars are issued there is a general rush for them by merchants, clerks, and coolies, who turn them over to the dealers for a consideration; but, as a rule, there is only a half-hearted attempt on the part of business houses to get these calendars into proper hands, as the best an advertiser can wish for is that his advertisement will be bought and paid for. There can be seen in the Chinese cities displays of dealers in calendars on walls and in alleys where the dealers do a good business at profitable prices. One calendar issued by an insurance company in Shanghai, and costing a little over one dollar Mexican (2*s.*), sold for 2·50 dollars Mexican (5*s.*) in the shops, and was in good demand at that. As in all advertising to the Chinese, the greatest care should be taken in design and wording.

House-to-House Distribution.—Folders, booklets, samples, and other advertising matter are often distributed not only in the cities but in the country towns. Rather than house-to-house, this is more appropriately called shop-to-shop distribution. It is expensive, unless done in a large way, and in close connection with a sales campaign. An advertising agency has worked out a plan for such distribution in Tientsin, whereby the shop receipt for the advertising matter is placed in a book with his company stamp or chop. While this system is slower than the usual one, it is more impressive with the Chinese and provides absolute proof of distribution.

Window Display and Stock Arrangement.—The British-American Tobacco Company has pioneered many of the problems of advertising in China, and one of the most remarkable of its means of reaching the public is the way it has trained the dealers to arrange their stock neatly and to make attractive window displays. Before the war the German manufacturers of a dentifrice did some good work in the direction of window display. Naturally this development has been under the direct supervision of foreigners, and if it is to assume any proportions, involves a large staff, which only concerns like the tobacco, drug, and oil companies have available.

Foreign Press.—The subject of the foreign press has been reserved for the last in order to leave a vivid impression of its importance. The value of the foreign press as an advertising medium for the rank-and-file of the Chinese public depends largely upon the enormous influence the missionaries exercise in the land. Each one is the centre from which Western civilisation radiates. If the Chinaman does not respect the missionary's religion he does respect his clean and self-sacrificing life, and the missionary, generally, is among the most highly placed men in his district. He is usually the personal friend of the Taotai (the high district official), and his position as an educator or physician places him high in the social scale. Outside of Treaty Ports the missionaries constitute the most considerable number of subscribers to the foreign press. The local English-reading Chinese call and ask to see the papers giving news that never reaches them through the native press. Practically all the higher officials in Peking, and in the Province, have translations made from the foreign press, and the rapidly growing number of English-speaking Chinese throughout the land occasionally look over these papers and are often more interested in the advertisements of Western manufactures than in the news columns.

CORRESPONDENCE.

"AVIATION AS AFFECTING INDIA."

I read with considerable interest the paper by Brigadier-General Lord Montagu of Beaulieu on the above subject published in the *Journal* of July 11th of this year, mainly because I am at present engaged on Major-General Sir W. Salmond's enterprise of establishing the aerial route between Cairo and India.

Last month (acting in command of a Handley-Page squadron) I had the honour of flying with the first organised unit from France to Cairo—ten machines in all. The total flying time of each machine roughly averaged forty-five hours. The course which had previously been decided for us was no doubt rather "round about," but suited the performance of the machines, and an aerial route of the future should prove to be of great commercial value owing to the fact that it links up most of the capital and important towns of Southern Europe. I will state in sequence the places at which one or more of the machines landed. The stages were roughly worked out so that we did approximately 300 miles per day:—

1. Lille	—	Provin	Aerodrome.
2. Paris	—	Buc	,,
3. Lyons	—	Bron	,,
4. Marseilles	—	Istres	,,
5. Nice	—	Nice	,,
6. Pisa	—	San Giust	,,
7. Rome	—	Centocelli	,
8. Capua	—	Capua	,,
9. Foggia	—	Foggia	,,
10. Taranto	—	Pizione	,,
11. Valona	—	Piedmont	,,
12. Athens	—	Dekelia	,,

13. Crete — Suda Bay Aerodrome.
14. Sollum — Sollum ,,
15. Alexandria — Amria ,,
16. Cairo — Heliopolis ,,

There were many intensely interesting problems to cope with on the journey. Storms and bad weather were frequently met with, and owing to the heavy loading and climbing capacity of the machines, the factor of the physical features of the country which one had to cover was in some cases a very great one to be considered. It is this latter factor the importance of which the great non-flying public apparently do not yet fully realise. For some time to come aerial routes must needs be a long way out of the straight route between the trading towns or places of descent.

I think it is obvious to all that for the present the carrying of merchandise, mails, etc., over a considerable distance to be a paying concern must be done by "lighter than air" aircraft. Landing grounds and refilling depôts are very costly in their upkeep, and until aeroplane designers have greatly improved upon the general efficiency and endurance of "heavier than air" aircraft for rapid transit of mails—say from England to America, Australia and the Far East—the airship seems to be the only practical medium.

I hope soon to be in a position to write informing the Society that the Cairo-Indian Aerial Mail Service is at any rate a running concern, despite the numerous difficulties, known and unknown, which will have to be overcome.

T. Henderson, Capt.,
Commanding Central Air Communication Station, Royal Air Force, Basra.

August 24th, 1919.

NOTES ON BOOKS.

A Treatise on British Mineral Oil. Foreword by Sir Boverton Redwood; Editor, J. A. Greene; Contributors, E. H. Cunningham-Craig, W. R. Ormandy, F. M. Perkin, A. Campbell, A. E. Dunstan, A. H. Seabrook. Folding plates and other illustrations. London, 1919: Charles Griffin & Co. 21*s*. net.

Opportunely in relation to the needs of the present time, the above-mentioned workers give us a book of 224 pages in which the present aspect of the problem of oil distillation from British minerals is very thoroughly considered, the various writings being so unified that the whole reads sequently as a current present-day essay on the subject. An exhaustive handbook on all aspects of oil production in the compass of 224 pages of rather large and open print is out of the question; but if we regard the work as one addressed mainly to technicians, manufacturers and financiers, in relation to the many problems involved in the question as to whether Great Britain can advantageously manufacture her own mineral oil, we must consider the book as highly satisfactory and comprehensive.

It must not, however, be supposed that because the work before us deals satisfactorily with the many problems involved in the main question, that the main question itself is solved. To ascertain whether our country can be self-supplying in the matter of mineral oils, or even whether an extended industry is practicable, must necessarily involve large outlay, resulting may-be in profit, but with a possibility of loss. The question of obtaining free or ready-formed petroleum by drilling is casually mentioned (p. 63) as "a speculative enterprise that may very probably meet with a scientific success but a practical failure," but a study or detailed consideration of the aspect is outside the scope of the work.

As regards the prospects of commercial success by the distillation of the various carboniferous shales (otherwise worthless or nearly so), of which we have several extensive deposits, a much more optimistic view is taken, but it is fully recognised that success depends on the adoption of the best known modes of economising fuel, and the most careful study of details in works organisation.

Those systems of retorting and producer-gas generation which promise well by the light of modern practice are sufficiently illustrated and described, while references to many of the original papers, descriptions, and tests are given in a bibliography; it must, however, be remembered that the leading tests and data are included in the text of the work.

The bibliography, like the work itself, is mainly concerned with the current or present-day aspect, but in the event of a second edition it would probably be well to widen the scope of the bibliography somewhat for the benefit of any readers wishing to extend their studies. A mere mention in the bibliography of the Patent Office Catalogue of Works on "Peat, Destructive Distillation, etc." (Patent Office Library; Subject List, YK.-YM. 108 pages 6*d*.) would in itself be a very great virtual extension of the bibliography.

Every student of chemistry knows how the highly complex tissues and organs of animal and vegetable origin, when subjected to destructive distillation, give a residue of carbon while the more stable hydrocarbons are leading characteristics of the distillate. Low-temperature distillation, as contrasted with the high-temperature distillation of the gas works, favours the production of those members of the paraffin series which have value as mineral oil, and range from motor spirit to paraffin wax. Hence low-temperature distillation is the keynote of the work before us. For over fifty years the distillation of the better-class Scottish shales has existed as an industry, but with heavy vicissitudes: recently, however, with "remarkable prosperity" (p. 3). Whether the lower grade shales of Norfolk and Dorset can be profitably treated is another matter, but it is well considered from various aspects (pp. 23, 73, 107, 99).

The case is widely different with respect to the distillation of oil from peat, lignite, cannel and other coals, or like materials, as these all have a high commercial value and many industrial uses. Hence a good yield of oil and by-products is a certainty, but the main factor of uncertainty is the balance of value between distillation and other uses. A feature to be considered is that on distillation all the products in this latter category yield residual coke suited more or less for domestic and factory use, so distillation does not entirely withdraw them from other uses, which are very thoroughly considered by our authors.

THE TIMBERS OF INDIA. By Alexander L. Howard. London: William Rider & Son. Price 2*s*. 6*d*.

In this pamphlet, which is illustrated by some excellent photographs, Mr. Alexander L. Howard, the well-known authority on timber, has written a descriptive catalogue of some forty of the most important Indian woods. It is probably quite true, as he remarks, that if the average man, even one accustomed to use timber, was asked what Indian woods there were, he would probably answer "teak," and be at a loss to name another. As a matter of fact, India possesses a great variety of woods, suitable for all manner of purposes, from heavy constructional work to the delicate craft of the cabinet maker. There is little doubt that markets could readily be found for all these if their qualities were once recognised, and if regular supplies could be guaranteed. With regard to East Indian rosewood, for instance, Mr. Howard believes that its uses—at present practically restricted to the pianoforte trade—might be very greatly multiplied, and he adds: "perhaps it might stimulate the efforts of the Indian Forestry officers to produce supplies more speedily if it were generally known that the product of only part of one English-grown tree, when handled and marketed by an expert, realised more than £1,000 sterling."

Probably the chief difficulty that confronts the Indian forest authorities is transport; but that is a difficulty by no means restricted to India. "The experience gained in this country during the four years of war," writes Mr. Howard, "has taught us much about transport, and it is fortunate that at least one Indian forest officer has been here and taken part in the organisation which it was necessary to establish for the logging, transport, and conversion of timber here; and as a result of the experience which he has already gained, much may be expected on his return to India."

GENERAL NOTES.

ROADS AND RAILWAYS.—At a conference of delegates of corresponding societies held at Bournemouth during the meeting of the British Association, a paper on "Roads, Ancient and Modern," was contributed by Lord Montagu of Beaulieu. With the recent increase in the the cost of labour on railways and the cost of handling goods it must be doubted, he said, whether railways without help in the form of subsidies or otherwise could hope to retain a considerable proportion of the traffic they had hitherto carried. For many purposes road transport in Great Britain would be in future the cheapest and most convenient way of carrying passengers and goods. The country, however, was in a transitional stage, and only practical experience and economic facts could decide how much traffic would be road-borne or rail-borne. Railways tended to concentrate populations. Road transport tended to disperse them. Railways did not like to be bothered with the expense of providing small country stations; road transport, on the other hand, could go anywhere. Light railways, from their fixed character and high cost of operation, were inferior to mechanical road transport for country districts. The number of tons per hour over a good main road was greater than the tonnage over even a double line of railway and from origin to destination was faster.

PHOSPHATE DEPOSITS IN THE SOUTH PACIFIC.—Extensive phosphate deposits on Nauru or Pleasant Island and Ocean Island, situated about midway between the Marshall and Solomon Islands, north-west of New Zealand, are said to be the most valuable deposits of the kind in the world. The islands, of coral formation, have for ages been the rookeries of sea birds, which have deposited guano that has impregnated the limestone, forming phosphate rock forty feet in depth. The quantity of phosphates available, writes the United States Consul-General at Auckland, New Zealand, is estimated at 500,000,000 tons, and as a fertiliser it is said to rival the famous nitrate fields of Chile. This phosphate possesses 85 per cent. of manurial value, as against about 27 per cent. for the best English phosphate, according to a statement in the *New Zealand Dairyman*. Before the war these islands belonged to Germany, but during the war they were taken over by the British Government.

JAPANESE TRADE IN CHINA.—H.M. Commercial Counsellor at Shanghai directs attention to the predominating position that Japan has won for herself in the foreign trade of China. Ten years ago the total value of Japan's imports and exports only exceeded Great Britain's total by 4,000,000 taels. To-day Japan's trade with China equals that of the whole of the British Empire, including Hong Kong, and if her share in Hong Kong's trade could be correctly ascertained it would undoubtedly be found to exceed the British Empire's total by a very considerable amount. It is not considered, however, that Japan can maintain this predominance, which is largely due to the fact that she was hardly touched by the trade disabilities and restrictions imposed on all European countries and the United States of America owing to the war.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes in the City of Westminster.—September 26, 1919.

No. 3489. OCTOBER 3, 1919. Vol. LXVII.

JOURNAL

OF THE

ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847 for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,489. VOL. LXVII.

FRIDAY, OCTOBER 3, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

THE USE OF ELECTRICITY IN AGRICULTURE:

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

(*Continued from page* 701.)

ELECTRIC POWER.

As in the case of electricity for lighting, electricity for power may be produced on the farm itself, or, as is more generally the case, taken from a central station for public supply. In the latter case single-phase, two-phase, but more usually three-phase alternating current is supplied. Alternating current has the great advantage over direct current for power distribution that its pressure or tension can be raised or lowered by means of simple stationary apparatus known as transformers. Motors designed to work on low-tension electrical mains are both cheaper and safer than those designed to work on high-tension mains; while, on the other hand, electrical transmission at high pressure is much cheaper than similar transmission at low pressure. The employment of transformers, therefore, enables the dimensions of the transmission line and its cost to be kept as low as possible. The energy losses in the transformers are small, and the necessary alternating current motors and generators are cheaper than machines of similar size for direct current.

It was, in fact, the development of the three-phase alternating current system that made possible the great development in the distribution of electricity that has taken place in recent years. Its use enables motors of the squirrel cage type to be employed for most classes of work. These motors have no commutators or rubbing parts of any kind other than bearings to get out of order, and they are therefore, ideal for agricultural purposes.

All mechanical work consists in overcoming resistance, and to reduce to the smallest amount the cost of the energy necessary for such work it is necessary to employ agricultural machinery of the most suitable type and electric motors and accessories designed to meet the working conditions met with. Co-operation between the agricultural implement manufacturer and the electrical engineer in this question of design is of great importance if the best results are to be obtained. It is safe to say that the German farmer had at his disposal in the period immediately preceding the war electrical material designed specially to meet his conditions costing little to purchase, involving little cost for attendance, and when portable of a type that could be brought in an easy and convenient manner to those places where the work was required to be done. Some idea of the size of motor necessary for the usual farm operations may be obtained from the following table:—

Operation.	Approximate horse-power.
Ploughing	40 to 80 h.p.
Threshing	3 to 90 h.p., depending upon the size, construction, and output of the threshing machine, and upon the accessories, *i.e.* cleaning gear, straw press, automatic binder, etc.
Chaff cutting	2 to 10 h.p., depending upon the output and accessories, such as sieve, cleaning apparatus, elevator, etc.
Flour mill	2 to 10 h.p., depending upon the fineness of the flour and the size, output, and system of the mill.
Corn cleaning	1 to 3 h.p., depending upon the type and size of the cleaners.
Potato crushing	0·5 to 1 h.p.
Oil-cake breaking	0·75 h.p.
Oat crushing	2 h.p.
Turnip crushing	2·5 h.p.

Operation.	Approximate horse-power.
Water pumping	1 to 3 h.p., depending on the quantity of water to be pumped and the height.
Sewage Pumping	1 to 2 h.p.
Sack hoists	2 h.p.

Electric motors are also employed for many secondary agricultural purposes and for rural industries and trades where, since the power demands are very fluctuating and the working period generally short, their advantages are particularly great. Approximate sizes of motor suitable for such trades may be obtained from the following table:—

Industry.	Kind of machine.	Approx. h.p.
Dairy work	Churns and kneading-machines of large size	3–5
Cart-making and joinery	Lathes, band saws, circular saws, drilling machines	3–5
Sawmills	Circular and frame saws, grindstones	3–8
Lock-making and smithies	Lathes, drilling machines, grindstones, bellows, ventilators	1·5–3
Bakeries	Kneading machines	1·5–3
Butchery	Meat-beating, mincing, and sausage-making	2–3
Printing works	Steam press	1–3

The following, among other advantages, are claimed for electrical driving on the farm where the motors and accessories are designed for the work they have to do, and the most suitable type for each purpose is chosen. These remarks particularly apply where three-phase motors are employed.

The motors are simple in design, and their first cost is low: thus, a 15 h.p. portable electric motor cost before the war less than one-third of the price of a steam or petrol traction engine of the same size.

They may be fixed in any position without expensive foundations, and may be readily started by merely closing a switch or turning a starting handle, no time being lost in heating or in turning round a crank-shaft as with heat engines.

For a given output the motors are small and light, and therefore portable and particularly suitable for agricultural work where the operations are of a temporary character and the work has to be carried on in different parts of the farm.

The power absorbed when running idle is very little, and a large overload capacity is provided to deal satisfactorily with fluctuating loads. The wear and tear is also small, and little care is required to run them beyond attention to lubrication. Finally, the even turning torque and freedom from reciprocating movement and its accompanying shocks have special advantages in particular cases, as for threshing and corn grinding.

In view of the absence on a large scale of electrical distribution for agricultural purposes in rural districts in this country, it may be well to describe in some detail the various elements of a typical Continental installation. In this connection reference may be made to Fig. 1, which gives a good representation of the distribution of electricity from a long-distance power-station and its connection to a motor in the field. On the left-hand side of the figure will be seen a permanent overhead three-phase transmission system carried on poles, which supplies electricity throughout the agricultural area from a central power-station. Temporary wires are shown connecting this high-tension overhead line to a transformer mounted in a wagon, and seen in front of one of the poles. The high-tension current is changed in this transformer to low-tension current, and this low-tension current is fed through a cable, which can be seen lying on the ground, to a portable motor carried in a horse-wagon and shown on the left-hand side of the picture. This motor drives a threshing-machine by belt. The distance between the transformer and the motor may be as much as a mile, and the low-tension cable which connects the two is, for short lengths, carried on a drum mounted in the motor-wagon, and for longer lengths on a "creel" suitably mounted on a special wagon.

A description in detail of each element of such an installation is given under its separate heading.

Overhead Line.—The high-tension overhead transmission line employed for distributing electric power to agricultural districts is of the usual type, the only special feature being the method of connecting the high-tension line to the portable transformer wagons. This method is shown in Fig. 1, from which it will be seen that some of the transmission poles have mounted on them a special connecting device. This device is provided with copper supporting hooks for the portable connecting cables, and is made either with or without a switch.

(*a*) In the arrangement without a switch the copper hooks are insulated and supported from an angle iron fastened to the pole.

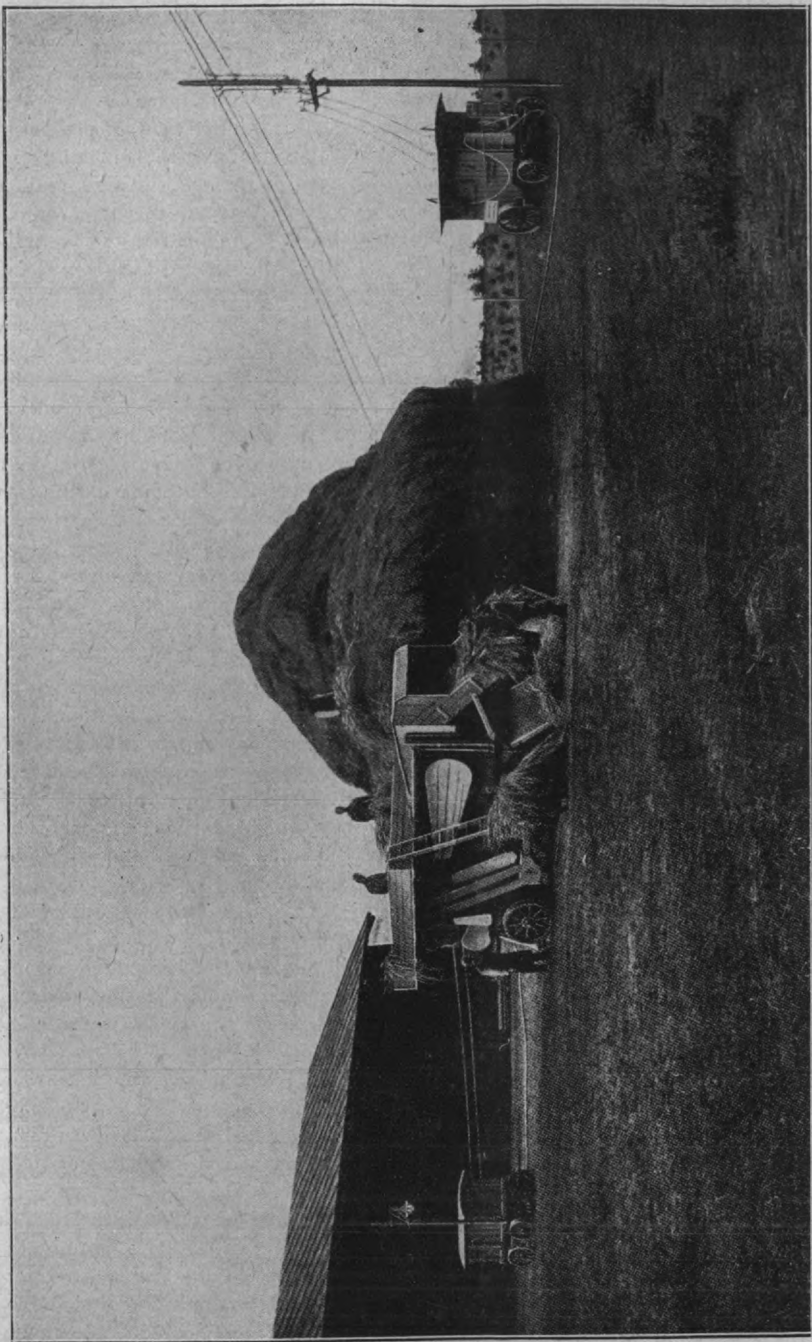


FIG 1.—THRESHING BY ELECTRICITY.

HIGH-TENSION OVERHEAD LINE WITH SWITCH AND CONNECTIONS TO TRANSFORMER WAGON (ON THE RIGHT) WITH LOW-TENSION CABLE CONNECTING TO MOTOR WAGON (ON THE LEFT).

(*b*) In the arrangement with a switch the copper hooks are insulated and carried on a shaft parallel to the angle iron. In this case they are provided with horn-shaped extensions which, when the switch is closed, make contact with somewhat similar horn-shaped fixed contacts which are insulated and supported from the angle iron fastened to the pole. These horns work in a similar way to the usual horn-type switches used for high-tension plant. A switch rod is provided as a part of the transformer wagon equipment, to enable the switch to be opened and closed.

Transformers.—For long distances, to avoid large losses in distribution and to enable conductors of small cross section to be used, it is essential, as has been pointed out, to transmit electric energy at a high voltage, and this makes it necessary to reduce the high voltage at the using point to a safe working voltage by means of transformers. These transformers may be either permanently fixed or portable, depending on the requirements.

Permanent transformers are employed when a supply of electricity is required for a sufficient time to justify their installation. In this country and in Germany permanent transformers are placed either in special buildings or in rooms set aside for their accommodation. In Canada and the United States, on the other hand, transformers especially designed for the purpose are frequently placed in the open air without any protection other than a rail or guard, and small transformers, similarly, are found mounted on the transmission poles themselves. These arrangements have the great merit of cheapness, and deserve more consideration from power-station engineers here than they have yet received.

The portable transformers are generally carried in wagons, and a typical German design is shown in Figs. 1 and 2. These wagons are substantially built with wooden wheels, the front wheels being, for the large size transformers, about 800 mm. diameter and 120 mm. wide, and the back wheels 1,200 mm. diameter and 150 mm. wide. The large diameter of back wheel enables the wagon with its transformers to be moved without difficulty over bad roads and in fields, etc., and to enable these to be fitted the back axle is bent downwards at the centre. Strong springs are provided for both axles to protect the transformer from vibration, and a strong hand brake, the operating handle for which may be seen in Fig. 2, is also fitted. These portable transformer wagons are employed in great numbers for pressures from 5,000 to 30,000 volts on the high-tension side and capacities varying from 25 to 100 k.v.a., for agricultural and other purposes. A usual size for such a transformer for agricultural work is 70 k.v.a., and the working weight of the wagon complete with such a transformer is about 3,000 kgms. Such a wagon can be hauled along level roads without difficulty by two fairly strong horses. A driver's seat is not provided as the drivers are not encouraged to drive quickly. The interior of the wagon is divided into two compartments by means of a partition, both compartments being provided with a suitable locked door to prevent unauthorised access.

The high-tension compartment contains the transformer, usually of the standard oil-immersed type and designed to withstand the strains which the wagon receives in rough agricultural work. Depending on the size and voltage of the transformer and on the rules of the power supply authorities, either fuses or an automatic oil switch are provided as a protection on the high-tension side so as to open the circuit on overloads. For voltages above 5,000 volts, choking coils are also used to prevent damage to the windings from excessive voltage, as for instance in the case of lightning.

The low-tension compartment contains fuses, a watthour meter and a cable connecting box, and the low-tension apparatus is in duplicate when the transformer is arranged for two different low-tension voltages, to enable it, for instance, to be used for ploughing and threshing, for which frequently different voltages are employed.

The connection between the high-tension side of the transformer and the transmission line is made at one of the poles, which carries a connecting device, such as has already been described. For connecting the transformer to this device three bare or insulated conductors are provided, fitted with rings at one end. These rings are placed, by means of the insulated switch rod already referred to, on the hooks on the pole device, the other end of the conductors being attached to terminals permanently connected to the transformer and carried on insulators on the roof of the wagon.

The length of portable conductor may vary from three to six metres, to suit different heights of pole and to keep the wagon, when necessary, a few metres away from the pole.

In exceptional cases short auxiliary high-tension conductors carried on poles may be

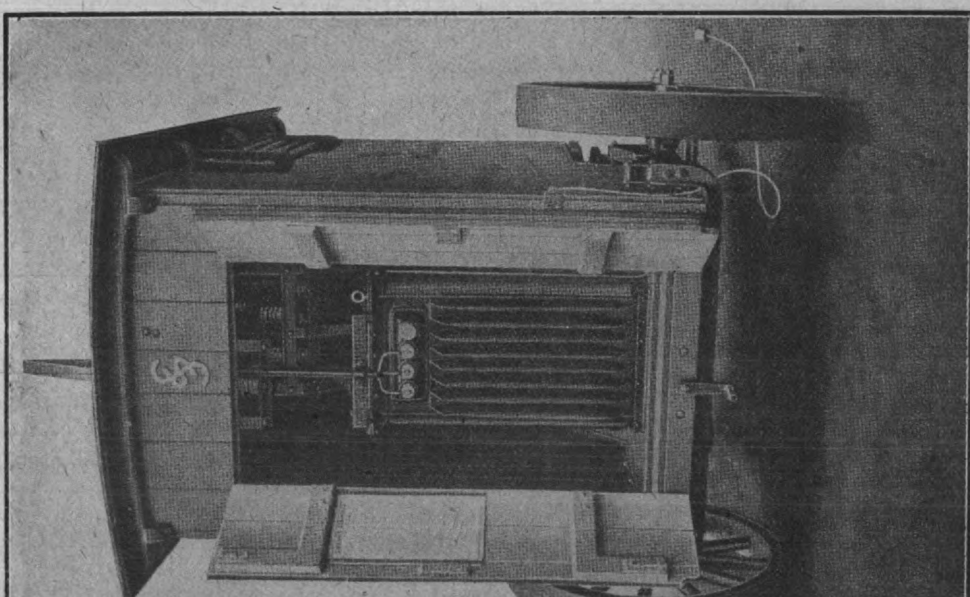


Fig. 2.—Transformer Wagon.

High-tension Compartment Open, showing Three-phase Transformer, 15000/1000 Volts and 15000/380 Volts.

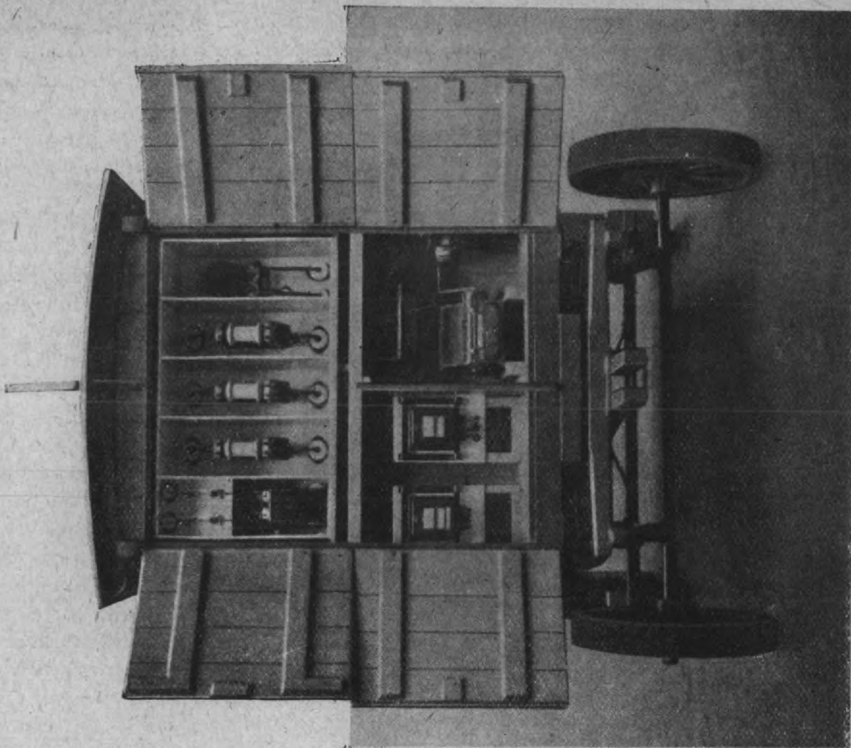


Fig. 3.—Transformer Wagon.

Low-tension Compartment Open, arranged for 1000 Volts and 380 Volt Low-tension Tappings.

necessary to connect the transformer to the high-tension line, but the cost of such additional conductors need not be excessive.

The conductors are only attached or removed when there is no current passing, and both insulated rod and the wagon are provided with an earthing device.

The portable electric transformer has a specially important part to play in agriculture, and in view of its advantages many of the larger central stations in Germany are providing these transformers in increasing numbers for supplying on hire.

Portable Cable Creels.—A flexible cable is necessary to connect each portable motor, or the winding wagons in the case of electric ploughing, with the low-tension side of the transformer. Each small motor is provided with a short length of such cable, ending in a suitable connector. This cable is shown lying loose in Figs. 5 and 6. The larger motors, carried on a motor wagon, are sometimes provided with a cable drum, Fig. 8, and this cable drum is capable of carrying up to 300 metres of flexible cable. Additional lengths of cable must be carried on a portable cable creel carried on a special wagon (Fig. 4). Where the distances to be covered are greater than 300 metres, separate lengths of cable are used, and these are provided with plugs and receptacles so that they can be easily joined together. Each receptacle is fitted with a switch so that it may not be possible to switch on the current until the cables are properly connected. The total length of cable used may be as much as 1,000 metres, and its division into separate lengths of 300 metres is made so that only the necessary length of cable is connected in each case to suit the length of land to be ploughed, and in this way unnecessary waste of labour is avoided and also the number of workers is reduced.

The transformer wagon itself, as already mentioned, carries a low-tension cable drum and 300 metres of cable, when it has not to carry choking coils for protection in extra high-tension work. The insulation and outer covering of the flexible cable are in all cases such as to withstand the rough usage received in ploughing and similar work based on practical experience.

Electric Motors.—The applications of electricity for power purposes in agriculture fall generally under two headings: (*a*) where the electric motors are permanently installed in particular positions; (*b*) where the electric motors are portable and only introduced when and where they are required, as for the operation of threshing machines, ploughs, etc.

It is recommended that motors should be permanently installed where the work is of such a nature as to require regular repetition at short intervals of time, and generally where the machine to be driven is permanently fixed, as, for example, in many pumping plants where the motor is switched on and off automatically. In such cases the motor may either drive a group of machines by chain gearing or by belts, on the system known as "group electric driving," or each machine may be provided with a special motor. The latter system is called "individual electric driving," and has much to recommend it.

Portable motors owe their origin and construction principally to the peculiar working conditions in agriculture, and are suitable for those cases which very often occur in agricultural work, where the various machines over the estate do not all require to be used at one time, but one after the other for a short period. In such cases the provision of a special motor for each machine would not be economical.

The portable electric motor also has the special advantage for agricultural purposes that it can be easily brought to any place where the work has to be done, and can be used without any danger of fire, which exists with gas, petrol or steam traction engines, even when the greatest precautions are taken. Electric motors can be used, for instance, in barns, forage lofts, corn lofts, etc.

Portable motors may be divided into the following classes depending on the method adopted for transporting them from one place to another:—

	Size of motor.
(*a*) Motor cradles . . .	0·3 h.p. up to 2 h.p.
(*b*) Motor sledges . . .	2·5 to 11 h.p.
(*c*) Motor trucks . . .	2 to 14 h.p.
(*d*) Motor wagons . . .	(1) 10 to 20 h.p. (2) 20 to 40 h.p. (3) 40 to 55 h.p.

All these various types are connected to the low-tension conductors by a flexible insulated cable attached to them. A plug is fastened to the free end of this cable, which can be inserted into the permanent socket on the supply circuit, which may, for instance, be attached to the wall of the barn or to one of the poles of the overhead line, etc. The plugs and sockets, and the outer cover of the cable have to be specially designed to meet the severe requirements of rough agricultural work. The speed of the

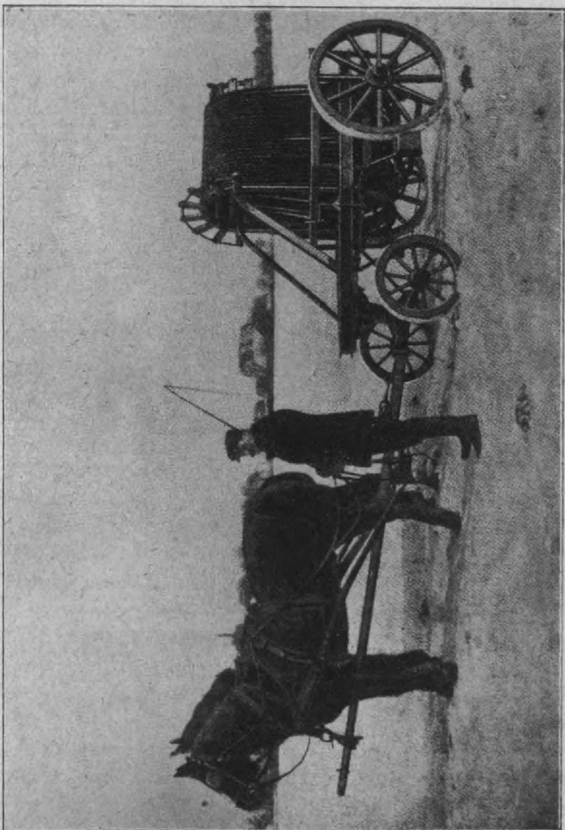


FIG. 4.—PORTABLE ELECTRIC CABLE CREEL.

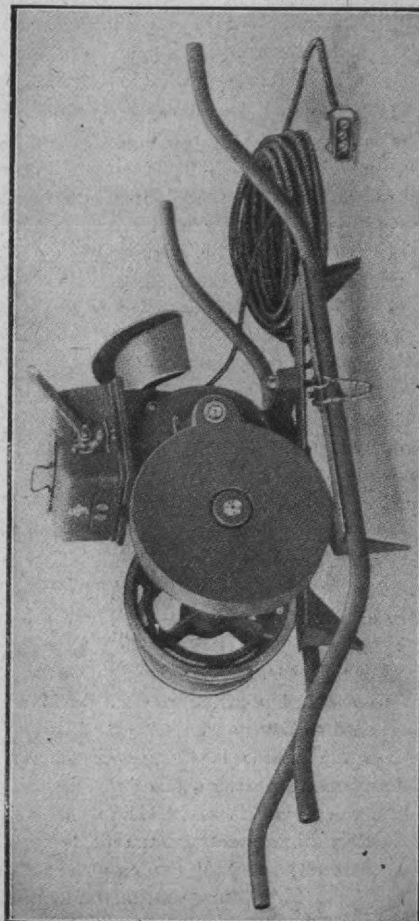


FIG. 5.—PORTABLE MOTOR CRADLE WITH SELF-CONTAINED GEAR REDUCTION.

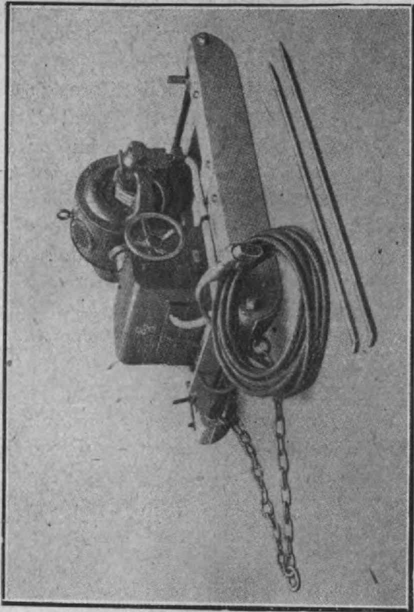


FIG. 6.—PORTABLE MOTOR SLEDGE (MOTOR PROTECTING COVER REMOVED).

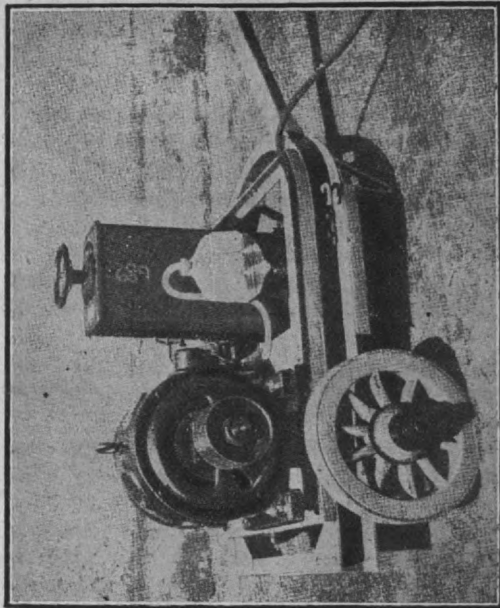


FIG. 7.—PORTABLE MOTOR TRUCK (MOTOR PROTECTING COVER REMOVED).

motors is usually 1,000 or 1,500 r.p.m., and they are supplied for the standard supply voltages.

(*a*) Dealing first with motor cradles. In these a standard three-phase motor is supported on a wrought-iron frame fitted with carrying tubes, which can be removed (Fig. 5). The motor is completely enclosed to protect it from injury and to prevent the entrance of dust, moisture and air containing ammonia, frequently found in agricultural work, for instance, in stables. Owing to the dust in straw-cutting or in fodder lofts, it is very desirable that the motors should be provided with rain-proof and dust-proof covers. This has the advantage that the motors can be fixed in the open air and need not be brought back immediately to some covered place, which would interrupt work, if a light shower of rain should fall.

The cradles are supplied either without gear reduction or with a suitable toothed wheel gearing to give a gear ratio of 1·6, which is the gear ratio generally used. This enables the motor, which must be made for high speed (if it is to be of small weight and cost) to be used for driving slow running machinery. A sheet metal cover prevents the toothed wheels from being touched.

In order to make the motor cradles suitable for as many different purposes as possible they are provided with a belt pulley having two rope grooves. In the case of cradles without gear reduction the pulley is fastened to the motor shaft, and where gear reduction is used to the back gear shaft. If desired, the motor shaft, in the case of cradles with gear reduction, can carry another driving pulley provided with a rope groove, while pulleys of different diameters may also be fitted to the driven machines themselves. In this way the different speeds required to drive the individual machines in agricultural work can be obtained.

Owing to the limited space available for a motor cradle, the starting switch and safety fuses are fixed to the motor in a rainproof case. The safety fuses which serve to protect the motor from excessive overloading are so connected with this switch that they are only connected in the motor circuit when the switch is in the full working position, and are short circuited so that no current passes through them when the motor is being started up. This arrangement prevents the fuses blowing every time the motor is started, due to the proportionately high starting current, and thus expense is not incurred through exchanging fuse cartridges while, further, the motor is actually protected on the basis of its allowable overload capacity.

With the motor is usually included a 10-metre length of special connecting cable, one end of which is permanently fastened to the motor terminals. When the motor cradle is moved this cable is carried on a special cable saddle fixed to the motor, which is made to carry altogether about 30 metres of cable.

The weight of the motor and cradle of the 2 h.p. size with toothed wheel gear and pulley, and including connecting cable, is about 100 kgs. The complete cradle can thus be carried even up and down steps by two persons, without difficulty.

(*b*) Where motors are required which are too heavy for cradles, but for the movement of which wheels or wagons are not absolutely necessary, wooden sledges are used on which the motor and necessary switchgear are placed (see Fig. 6). These sledges consist of two wooden baulks with iron fittings as runners. These baulks are connected by wooden cross-pieces, and are provided with four wrought-iron hooks to which chains or ropes can be fastened for moving the sledge. When the motor is running these chains are fastened to suitable iron pegs in the ground. The motor, which is of the slip-ring type, and its switchgear are protected against moisture, etc., by a light, removable, sheet metal, ventilated cover which can easily be removed at any time to examine the apparatus.

As speeds of 1,500 and 1,000 r.p.m. are usually suitable for work for which motors above 2 h.p. are used, it is not usual to fit back gearing to these motors, which are, therefore, only fitted with a standard belt pulley of a size depending upon the output, and provided with two rope grooves.

To start the motor the trap door at the side is opened, and with motors up to about 5 h.p. a star delta switch is used, if the supply authorities do not object to the rush of current at start. If, however, a high starting torque is required, a drum type starter and resistance in the rotor circuit are used.

For outputs above 5 h.p. simple drum type starters suitable for the rough handling they are likely to receive in agricultural work are fitted.

Safety fuses are provided to protect the motor from excessive overloads, and are placed near the starter.

The special brackets for carrying the cable are fastened to one of the short sides of the removable cover.

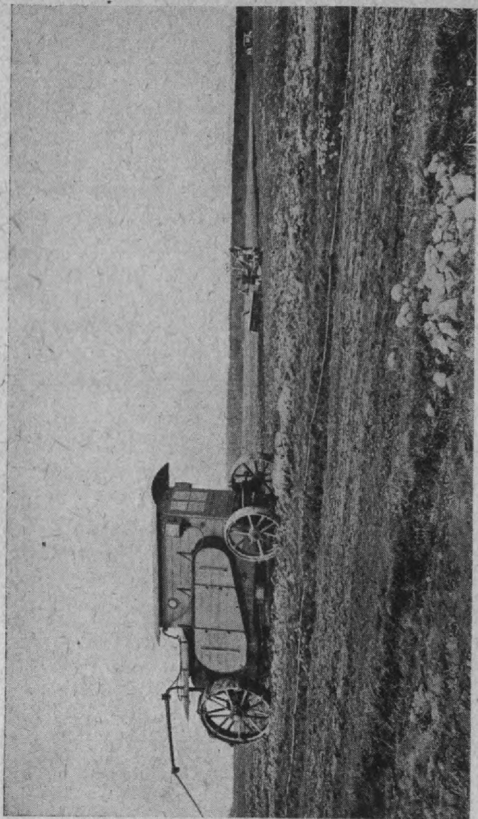


FIG. 9.—ELECTRIC PLOUGHING ON THE DOUBLE WINDER SYSTEM IN PROGRESS.

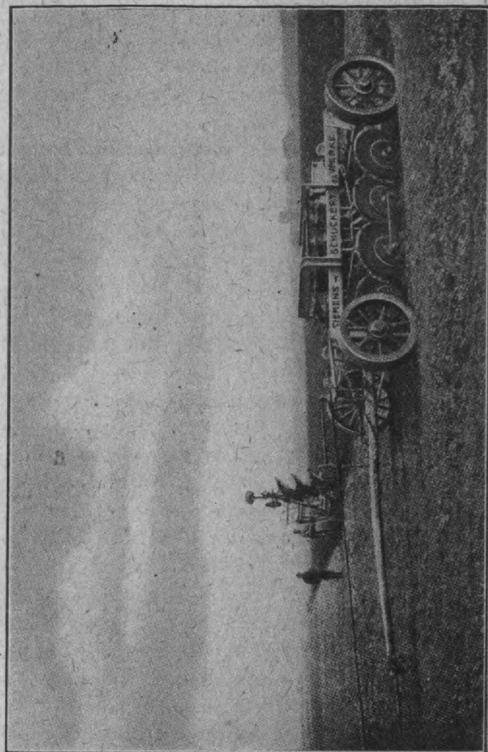


FIG. 10.—ELECTRIC PLOUGHING ON THE SINGLE WINDER SYSTEM, SHOWING ANCHORAGE WAGON.

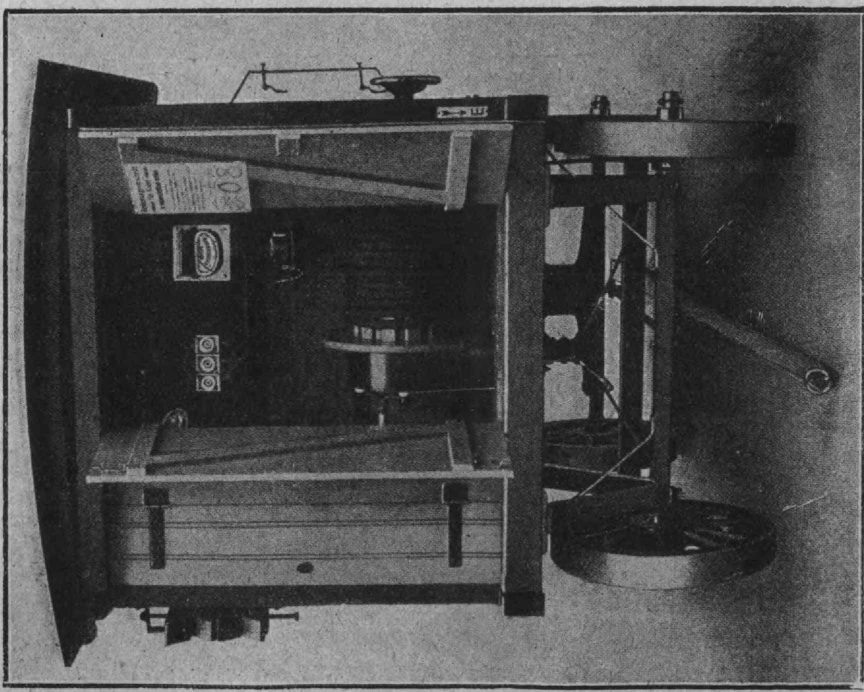


FIG. 8.—PORTABLE MOTOR WAGON, SHOWING CABLE DRUM.

(*c*) Motors too large to be conveniently handled if mounted on a cradle or on a sledge are carried on a motor truck (Fig. 7), which consists of a small two-wheeled truck which can be moved either by men or by animals, and on which is fixed an ordinary three-phase motor having a slip-ring rotor with the necessary switchgear. To protect the motor and its accessories, these may be of the rainproof type, or they can be of the ordinary plain type and protected against being touched and against rain, snow, dust, etc. by means of a sheet metal cover. To the back of this cover may be fixed the cable bracket to carry the cable when the truck is moved. A trap door in the front of the cover, fitted with a bolt, gives access to the hand-wheel of the drum starter, and under this cover the main switch and fuses are also fixed.

(*d*) The motor wagon (Fig. 8) consists of a wooden wagon body with strong underframe and four wooden wheels with iron tyres. The diameter and width of the wheels is so large that the wagon can be easily moved even on bad roads. The interior of the wagon is usually divided by partitions into four separate compartments. In the first of these is placed the motor with its starting gear; in the second the cable drum; in the third the belt pulleys; and in the fourth, space is left for the necessary tools, etc.

The wagon body is supported by the two back wheels and by the pivot of the front wheels. It thus rests on three points, and can be used on uneven ground without fear of injury to the framework through unskilled handling. To fix the wagon at the working point, blocks are placed between the wheels and, in addition, the wagon can be supplied, if required, with a powerful hand brake.

The electric motor generally fitted is of the ordinary standard type, with a wound slip-ring rotor. It is started by a drum type controller drum rotated by a hand-wheel which can, if necessary, be changed from the right-hand to the left-hand side or vice versa, to save trouble in fixing the position of the wagon.

In addition to the starting regulator, a main switch is provided by which the motor can be entirely switched off from the overhead line. This main switch is attached to the starting regulator so that the working of the motor is completely controlled by the movement of the hand-wheel of the starting regulator. To protect the motor against excessive overloads, suitable fuses are provided. The cable is wound on a cable drum, shown in Fig. 8, or supported on cable brackets in the interior of the wagon body. In the former case, the connection between the cable and the motor is made by slip-rings fixed on the cable drum. In both cases plug connections are unnecessary and thus wear and tear on the cable is saved, as well as time, since in using the motor it is only necessary to uncoil the length of cable corresponding to the distance between the wagon and the point of supply.

To the posts of the wagon body a small saddle bracket can be bolted for holding the coiled cable, and also a small iron bracket arm for supporting an electric light fitting, so that threshing, for instance, can be continued without much trouble when it is necessary to work during the night. For this purpose the pole carrying the electric light fitting projects high above the wagon and is easily maintained in a vertical position.

Applications.

Some applications of electricity on the farm are of sufficient importance to merit special description, and under this heading may be classed electricity applied to ploughing and to threshing. In connection particularly with the former, considerable technical skill has been displayed in the design of suitable apparatus to meet conditions in the field, and much success has been achieved.

Several of the larger electrical manufacturing firms actually design and manufacture ploughs suitable for working with the electrical apparatus they supply.

Ploughing by means of electricity has latterly made considerable progress in Germany, but its progress at the beginning was slow. The power required for this class of work is fairly considerable, and many of the smaller power-stations were unwilling to accept the load. Now, however, central stations of considerable size have been erected in most areas, and consequently development has been rapid. To enable central stations to develop and supply energy at a cheap rate, it is important that their load should be evenly distributed throughout the year, and the development of electric ploughing in agricultural districts helps the central stations distributing in rural areas to maintain this even distribution.

Ploughing, it is generally found, can be so arranged in connection with other classes of farming work that when the electric ploughs are in use other electrically-driven machines are either not in use or only partially employed, and by this means the load is averaged during the periods of working.

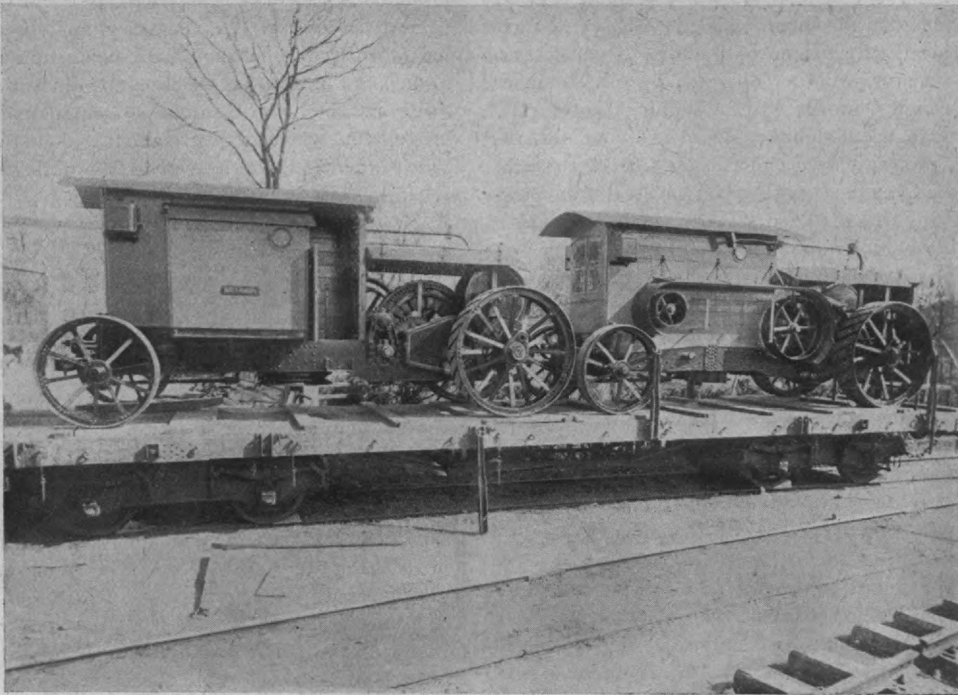


FIG. 11.—WINDING WAGONS IN TRANSIT ON RAILWAY TRUCK (DOUBLE WINDER PLOUGHING SYSTEM).

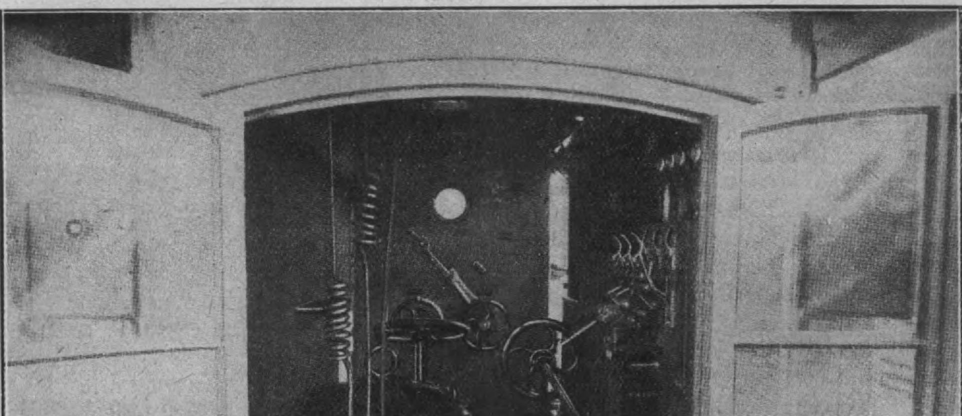


FIG. 12.—ELECTRIC PLOUGHING, SHOWING INTERIOR VIEW OF WINDING WAGON.

Mechanical ploughing is generally carried out either (*a*) by means of tractors, in which case the motor, whether operated by oil, steam or electricity, moves with the plough across the field to be ploughed; (*b*) by means of stationary motors placed one at each side of the field to be ploughed, with a single steel cable traversing the distance between them, the plough being hauled in one direction by one motor and in the other direction by the other; or (*c*) by means of a single motor placed at one side of the field and a winch at the other, the plough being moved from one side of the field to the other by a steel cable which passes from cable drums on the motor round the winch.

Tractors operated by oil and steam have come much into use of recent years, but electrical tractors have scarcely emerged from the experimental stage.

Electric Tractor Ploughing.—The most practical attempt to provide an electric tractor was that of Zimmerman, who placed anchors at each side of the field to be ploughed, with a stretched chain between them. A large plough, of the type used in the Fowler system, carried an electric motor, which engaged, by means of cog gearing, with the chain and so moved the plough across the field. The chain anchors were moved forward when necessary, and current was supplied to the motor by means of an insulated cable carried on suitable supports and connected to a transformer wagon. This system has not been very successful, and has only been used for light work.

Ploughing by two stationary motors, or a stationary motor and winch has, on the other hand, found much favour with electrical engineers, and several Continental firms have put excellently-designed apparatus suitable for these systems on the market.

Two distinct types of apparatus have been developed—one of a heavy type, manufactured principally in Germany and latterly also in France, and the other of considerably lighter construction developed in France. It may be said that the heavy type has so far been the more successful, and that its best development has been in Germany, where the Siemen's winch and winding wagons, described in this paper, are much in use.

Double Winder Ploughing.—In this system of ploughing two winding wagons, generally similar in design, are placed one on each side of the field to be ploughed. Each winding wagon, typical examples of which are illustrated in Fig. 11, carries an electric motor, the necessary switchgear, mechanical gear, and the plough cable haulage drum. The working weight of the type illustrated, which is of the heavy German pattern, including wire rope, but without cable, is about 13,000 kgms. Some dimensions are given in the following table:—

	Length. Metres.	Width. Metres.	Height. Metres.
Overall dimensions . .	6·60	2·60	3·00
Wheels, front	—	0·33	1·30
Wheels, back	—	0·50	1·80

The wagon consists of a strong framework strengthened in suitable places by cross and longitudinal members and supported at the rear by the back wheels and at the front, through a strong steel pivot over a beam, by the front wheels in the manner already described for motor wagons. It is thus always supported at three points, namely, the two back wheels and the pivot of the front beam, and thus all twisting and straining are prevented and the framework is not affected by the unevenness of the ground. The steering of the wagon is done from the driver's position in the motor compartment by turning a hand wheel in the direction in which it is desired to go. The neutral position of this wheel, on which the wagon will move straight forward, is indicated by a special mark. The front wheels are fixed in the manner usual to motor-car practice, so that the steering is done by the movement of the wheels and not by the rotation of the front axles.

In one design of this winding wagon the front part is fitted with a locked driver's cabin, which encloses both the electric motor and the steering gear, while the rope drum at the back of the wagon and the mechanical gearing are protected against rain, snow, etc., by a plain metal roof. In another design the driver's cabin, which, as in the previous case, contains the electrical equipment, is replaced by a plain roof covering the whole wagon.

A strong brake is provided which can be applied both from the rear of the wagon and from the driver's cabin by means of a foot lever, which is interlocked with the electric switch, and so cuts off the electric current if any hindrance or danger suddenly occurs during the ploughing or during the back and forward movement of the wagon itself.

To enable the wagons to progress better on soft and slippery ground, special attachments can be made to the back wheels and cutting flanges are sometimes fastened to the front wheels to prevent the front of the wagon being pulled round. The length, width and height of

the wagons are such that they can conveniently be loaded on to an ordinary flat railway bogie, and Fig. 11 shows such wagons arranged for railway transport on a bogie.

On good roads the winding wagons can be moved by six or eight horses, and for this purpose a strong shaft is fastened to the pivoted beam at the front of the wagon and so connected that the steering of the wagon is not done by the steering wheel, which is disconnected, but by the movement of the shaft. Under difficult conditions of transport, as on slopes or sandy ground, the wagon can be moved by fastening one end of the haulage cable to the ground at a suitable point, coupling up the motor mechanically to the cable drum as for hauling the plough and pulling the wagon backwards and forwards as may be desired.

(To be continued.)

ARENGA FIBRE IN THE DUTCH EAST INDIES.

The arenga fibre is obtained from the fibrous mass which persists in the form of a network of long black fibres on the sheaths of the leaves of the arenga palm (*Arenga saccharifera Labill*), after the old leaf stalks have decayed. This material can be separated from the trunk in masses. It is known to the natives under the names of gemutu, duk, and indjuk. They use it as roofing material and for the manufacture of cordage and of small stiff brushes; occasionally also as binding material in the building of houses and of pirogues for inland navigation.

In Europe, too, there is a demand for the arenga fibre, which is noted chiefly for its great resistance to water; its tensile strength, however, is only half that of hemp, and the fibre, it seems, cannot be used for the manufacture of paper. According to the official American "Commerce Reports," tests undertaken by the Government of the Dutch East Indies have shown that these fibres are an excellent material for the coating of submarine cables (owing to their resistance to water); the fibres can also be manufactured into brushes. They are less adapted for the manufacture of cordage on account of their coarseness and lack of elasticity.

The arenga palm grows wild throughout the Indian Archipelago, so that considerable quantities of the fibres are available. The natives cultivate the palm for its sago, palm sugar, and palm wine.

The preparation of the fibres for export is very simple, consisting merely of cleaning, sorting and packing. The exports of arenga fibres from Java and Madura during the years 1913–16 were as follows, the bulk going to the Netherlands:—

	lb.		lb.
1913 . .	255,957	1915 . .	114,678
1914 . .	220,096	1916 . .	185,878

It is expected that the exports of these fibres will largely increase in the future.

PARAVANES.*

The Paravane has been developed as a weapon to fulfil two purposes—(1) to attack a submarine; (2) to protect vessels from moored mines.

In order to differentiate between the two, the one used for attacking submarines is termed the "Explosive Paravane," and the other for protecting vessels against mines is called the "Protector Paravane." A further differentiation in Protector Paravanes has been to call all those used for protecting warships "Protector Paravanes," and those used for protecting merchant vessels "Otters."

The basic principle of all three is the same. They are in effect a form of water-kite which can be towed by a vessel and will run outwards and downwards from the towing vessel.

The Explosive Paravanes carry a large charge, amounting in some cases to over 300 lb. of T.N.T. The Protector Paravanes, or Otters, carry a form of cutter, but no explosive charge whatever, the cutter being used for severing the moorings of the mines.

In general, a vessel fitted with either form of apparatus tows two paravanes, one on either side, by specially manufactured wires. A depth-keeping mechanism is fitted in the tail of the Paravane or Otter whereby the depth at which it is being towed may be previously fixed. Variations in the speed or course of the vessel thus have no effect upon the depth of the Paravane.

Explosive Paravanes are necessarily more complex than the protector type, and, in addition to their charge of T.N.T., carry the necessary firing gear and depth-recording device, etc. The explosive charge can be detonated by an electric current which passes through a core in the towing wire. Various methods of detonation, automatic or deliberate, are arranged. Safety devices are inserted in the firing circuit so that the Paravane cannot be accidentally fired whilst it is on deck or in the water near the ship.

The method of attack by the Explosive Paravane against a hostile submarine is for the attacking vessel to proceed to the spot where the submarine was last seen, and there to rake the water with the two Paravanes, which will be towed at a depth of perhaps 200 feet.

The success of the Explosive Paravane has been very remarkable, when it is realised that this form of attack is only used when other methods, such as the torpedo, the gun, or the ram, have failed. The only form of attack of a like nature is the depth charge. In comparing the results obtained by the Paravane with those obtained by the depth charge, statistics show that the depth charge destroyed four times as many submarines as the Paravane. Due consideration must be given, however, to the fact that depth charges were fitted in twenty-five times as many vessels, and accordingly, proportionately to the number of

* Abstract of a paper read before the Engineering Section of the British Association by Robert F. McKay, M.Sc., A.M.Inst.C.E., A.M.I.Mech.E.

vessels fitted, the Paravane is many times more efficient.

The action of a Protective Paravane or Otter can best be likened to a broad wedge being formed in the front of the towing vessel. Each Paravane is towed from a point as far forward and as low down as possible by a specially constructed steel wire, and the hydroplane on the Paravane exerts a heavy pull upon these wires. These wires, therefore, form a wedge, kept in place by the tension produced by the dynamic reaction of the water upon the Paravane. Mine-mooring wires which strike this wedge are deflected away from the ship, and passing along the towing wire are guided into the cutter jaws on the head of the Paravane and instantaneously severed. The mine-sinker drops to the bottom of the sea, while the mine floats to the surface, where it can be seen and destroyed by gunfire.

The success of the Protector Paravane or Otter has been even more striking than that of the explosive type. Out of just under two hundred British war vessels fitted with this device, fifty-three have cut mines involving a total tonnage of over half a million tons, and representing a money value of about sixty millions sterling.

Of British merchant vessels, 2,700 have been fitted, but, owing to less accurate reports being obtained from merchant vessels as compared with warships, the actual results are not known. If, in comparison with British warships, only one-tenth as many merchant vessels, as compared to the number fitted, have been saved, the saving to the country in tonnage has probably been much in excess of one hundred million sterling.

GENERAL NOTES.

New Zealand Coprosma Dyes.—Specimens of New Zealand dyes, made from several species of coprosma (grandifolia, areolata, fœtidissima, and lucida) by Mr. B. C. Aston, Chemist to the New Zealand Department of Agriculture, are shown in a recent issue of that Department's Journal. The colours range from yellow and brown and red, through intermediary tints, to black. Wool treated with these dyes was exposed during the whole of a winter month to rain, wind, and sunshine, and only one colour (the yellow of fœtidissima) faded. These dyes, according to the Journal, can be made easily by any household, and thus they can have a use in home industries. The value, in a commercial sense, remains to be seen. It is possible that the experiments with coprosma may reveal a dye compound not previously discovered, but when the chemical analysis of the new compound becomes known, it might be necessary to use constituents of coal-tar for the manufacture of the new dye on a large scale.

Preparation of Foodstuffs in India.—The Board of Scientific Advice for India in their last annual report mention that the Madras Agricultural Chemist and his staff have paid considerable attention to the possibility of utilising indigenous material for the preparation of foodstuffs hitherto imported in considerable quantities. They have been successful in preparing excellent examples of "shredded wheat," "grapenuts," vermicelli and macaroni, and have shown that flours prepared from South Indian leguminous seeds form a good substitute for pea flour. The most important fact they have brought out is that certain grains such as ragi (*Eleusine coracana*) and Cholam (*Sorghum vulgare*) are capable of producing excellent malts which can be used as a basis for preparing infants' and invalid foods of the types of the well-known Benger's and Mellin's Foods. In addition, a good malt extract can be readily prepared from them, and used for the production of "malted milk."

Germany and the Indian Textile Market.—H.M. Trade Commissioner in India, commenting on pre-war German competition, quotes a review of methods adopted to secure the above market. The manufacture of velvet in Germany is, or has been, larger than the home consumption. Germany, therefore, to get rid of her surplus stocks, used India as a dumping ground, underselling foreign competition. In 1909 the German makers formed a syndicate amongst themselves "with a view to regulating prices." In August of that year they sent out word that prices were going to be enhanced from and after the following January 1st, but that any orders placed before that date would be booked at old rates, even if shipments were to be made after January, 1910. With reference to post-war prospects, the Commissioner is of opinion that Germany has accumulated stocks, and that these will be shipped to India at the first opportunity. He suggests that the goods will sell at an advance of 50 per cent. on pre-war prices, stocks in India being depleted.

Trades for Demobilised Women.—A beginning has been made with the scheme for training demobilised women in skilled industry. According to a correspondent of "*The Times*" *Educational Supplement*, about 114 young women, all of them over eighteen years of age—the majority being over twenty—have been selected at the Employment Exchanges to receive maintenance grants of £1 to £1 5*s.* weekly while under instruction at special classes organised by the London County Council at one of the Trades Schools. Dressmaking, ladies' tailoring, upholstery, cookery, and the packing and sorting of articles for laundry work are taught. For the present the course of training is to be limited to six months in the needle trades and to three months in the other departments. No provision has yet been made for instruction in general education, but eventually there may be classes in drawing, design, embroidery and English literature. Doubtless other subjects will be added if the experiment meets with the success it seems to deserve.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—October 3, 1919.

No. 3490. OCTOBER 10, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,490. VOL. LXVII.

FRIDAY, OCTOBER 10, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

COLONIAL SECTION.

The Colonial Section Committee, as appointed by the Council, is as follows:—

Sir Henry Trueman Wood, M.A. (Chairman of the Council).
Lord Blyth (Chairman of the Committee).
Marquess of Aberdeen and Temair, P.C., K.T., G.C.M.G., G.C.V.O.
Octavius C. Beale.
Lieut.-Colonel Sir Charles H. Bedford, LL.D., D.Sc., M.D.
Earl Brassey, D.C.L.
Byron Brenan, C.M.G.
Richard Ernest Brounger.
Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.
Hon. James Daniel Connolly, Agent-General for Western Australia.
Hon. Sir John A. Cockburn, K.C.M.G.
Sir Edward Davson.
Edward Dent, M.A.
Sir Walter Egerton, K.C.M.G., LL.D.
Right Hon. Andrew Fisher, High Commissioner for Australia.
W. L. Griffith.
Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E.
Hon. J. G. Jenkins.
Major Edward Humphrey Manisty Leggett, R.E., D.S.O.
Hon. Edward Lucas, Agent-General for South Australia.
Hon. Sir Peter McBride, Agent-General for Victoria.
Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand.
George Robert Parkin, C.M.G., M.A., D.C.L., LL.D.
Sir Westby B. Perceval, K.C.M.G.
Sir Robert W. Perks, Bt.
Hon. Sir George Halsey Perley, K.C.M.G., High Commissioner for Canada.
Right Hon. Sir Joseph West Ridgeway, G.C.B., G.C.M.G., K.C.S.I.
Lieut.-Colonel Sir Thomas Bilbe Robinson, K.C M.G., K.B.E., Agent-General for Queensland.
Lord Sanderson, G.C.B., K.C.M.G.
Sir Thomas Sutherland, G.C.M.G., LL.D
Carmichael Thomas.
George Wilson, C.B.
Hon. Sir Charles Gregory Wade, K.C., Agent-General for New South Wales.
Sir Frederick W. Young, M.P.
S. Digby, C.I.E. (Secretary).

CANTOR LECTURES.

The Cantor Lectures on "The Scientific Problems of Electric Wave Telegraphy," by Dr. J. A. Fleming, F.R.S., Professor of Electrical Engineering, University College, London, have been reprinted from the *Journal*, and the pamphlet (price 1*s.* 6*d.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2)

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

THE USE OF ELECTRICITY IN AGRICULTURE:

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

(*Continued from page* 721.)

Double Winder Ploughing (*continued*).—A number of actual experiments were made in the year 1909 and the spring of 1910 to determine the motor capacities required for the Double Winder Ploughing system. According to these observations 14–16 kw. hours were consumed in ploughing 2,500 square metres, *i.e.* nearly two-thirds of an acre, to a depth of 20–25 centimetres in moderately heavy ground. When the resistance of the ground became greater, due to rain, 18–20 kw. hours were required, and the highest figures observed on the heaviest ground were from 22–24 kw. hours when the depth of furrow was 37–44 centimetres. The tests were carried out with a five-share reversible plough of 2·2 metres working width. The full capacity of the plough depends on local conditions, and on trials with a plough of the size referred to it was found that with a moderate winding speed of 1·65 metres per second and a furrow length of only about 400 metres, two acres could be ploughed per hour to a full depth of about 16 in. Similar trials with a three-share plough with an average speed of 1·6 metres per second and with a comparatively disadvantageous furrow length of only about

300 metres showed that a surface of $1\frac{1}{3}$ acres could be ploughed in one hour to a furrow depth of about 16 in. On the basis of these results and a working day of fourteen hours, which is the usual length of a Continental working day in the principal ploughing months, and taking into consideration the delays for changing the transformer wagon, etc., about 23 acres could be ploughed daily, a feat which has been actually accomplished on several estates. It is not possible, of course, to plough every day at the same rate without stopping. In unfavourable weather, and on account of other circumstances, one or other winding wagon may not be moved forward as quickly as is necessary to maintain the above output, and other delays may occur when the connecting cable has to be lengthened or the transformer wagon moved to the nearest connecting point, which has to be done usually about once a day, but in any case the average daily capacity should not be less than 19–20 acres.

As only one winding wagon is employed at the one time in the double winder ploughing system, while the motor of the other winding wagon is at rest during this pull, a smaller motor may be employed on this system than in the single winder system for a similar ploughing output. By this means, and by dispensing with one drum and the corresponding plough rope, the total weight of the winding wagon is reduced, or, in other words, for an equal working weight of motor the capacity of the double winder plough is greater than that of the single winder plough.

Four workers only are necessary for working the whole double winder ploughing system, viz., two winding wagon attendants and an attendant for the reversible plough, with an ordinary labourer to assist the latter. Among the advantages of the double winder system may be mentioned the following:—

(1) The extremely simple working of the whole plough set.

(2) Its suitability for large fields.

(3) Great surface capacity on the heaviest ground with deep furrows, and with small consumption of current.

(4) The possibility of fixing the winding wagons on very sloping ground, which is not possible in the case of steam ploughs.

(5) Smaller wear of wire cable than in the single winder system, because only one wire length is required to cross the field.

Single Winder Ploughing.—A complete equipment for single winder ploughing consists of (*a*) a winding wagon; (*b*) an anchorage wagon; (*c*) the haulage cable.

(*a*) The winding wagon for single winder ploughing carries the electric motor with its control apparatus, the gearing, and the haulage cable drums. The weight of a typical wagon without wire cable or electric cable is about 13,500 kgms. (13·3 tons), and the wagon is designed for a maximum pull of 4,000 kgms. (3·9 tons). Some dimensions of this wagon are given in the following table:—

	Length. Metres.	Width. Metres.	Height. Metres.
Overall dimensions .	6·4	2·6	3·5
Wheels, front . . .	—	0·33	1·3
Wheels, back . . .	—	0·5	2·3

The wheels are of ample dimensions to suit farming operations, and permit of safe and easy movement of the winding wagon even on soft wet ground, and also to provide the necessary stability. The electric motor is of the standard rainproof type, and the entire wagon is protected by a roof, the sides being open to give an unobstructed view, which is necessary with this system. A locked protecting cover can be provided for the driving gear, and when this is fitted a standard plain type motor may be used. The size of the winding wagon is such that motors of from 60–90 h.p. output can be used, and a ploughing set has recently been put on the market fitted with a motor of an output of 40 h.p. The power is transmitted, as in the case of the double winder wagon, from the motor shaft to the gearing by means of pulleys and belts, and the remarks made as to electrical and mechanical control gear and safety devices, the advantages of belt drive, etc., in describing the double winder wagon apply here also. Generally, the construction of the winding wagon for the single winding wagon system is similar to that for the double winding wagon system, but the mechanical gear for the single winding system is more complicated, since two cable drums are in use, the direction of rotation of which must be alternately changed. In the type of wagons described, the toothed gear-wheels, rope drums and main bearing housings are made of the best cast steel, and the shaft and axles of Siemens-Martin steel. The change-over two-speed gear enables the reversible plough to be hauled either at the moderate speeds of 1·1 or 1·6 metres per second without changing the gear wheels. With the same gear ratios the speed of the winding wagon itself can be 2·1 or 1·5 kilometres per hour respectively. These speeds are generally adopted but, if neces-

sary, by changing the pulleys the speeds can be altered within certain limits. The possibility of changing the speed of the haulage drum during work is of special advantage when the wagon is used for hauling turnip cutters or ploughing much neglected land. A number of clearly printed name-plates show the driver the purpose of the different levers, so that an intelligent farm hand, after a short period of instruction, should be able to drive the wagon, thus doing away with the necessity for skilled attendants.

(*b*) The anchorage wagon or winch used in the single winder system is illustrated in Fig. 10. It consists of a framework which carries the drums and pulleys with their gearing, the whole being supported on four wheels having deep stability flanges. Its total weight is about 4,000 kilograms (3·9 tons). In addition to the removable stability flanges on the running wheels, it is also provided with extra so-called anchorage flanges, the distinguishing feature of which is that the stability of the wagon increases as the pull on the plough haulage cable increases. The additional anchorage flanges are carried from the wagon framework on the movable frame between the wheels, which is so connected with the cable haulage pulley that the anchorage flanges are forced either perpendicularly or obliquely deeper into the ground as the pull on the haulage cable increases, thereby obtaining a firmer hold on the soil. These flanges have the great advantage that by their use the movement or tilting of the anchorage wagon towards the plough is reduced to a minimum. This is the case because the flanges are locked during ploughing, and include the period during which the anchorage wagon is moved forward. The flange surface embedded in the ground bears a fixed ratio to the pull on the cable, and the movement of the anchorage wagon towards the plough is avoided. The anchorage flanges can be put in or out of action by lowering or raising their movable framework, and the stability flanges on the running wheels are so arranged that they can be quickly and conveniently taken off, thus enabling the anchorage wagon to be easily moved along roads.

When the anchorage wagon is at work, it has fastened to it a special steel cable about 130–150 metres long, the far end of which is fixed in the ground. The object of this steel cable is to cause the anchorage wagon to move forward in a direction at right angles to the lengths of the furrow by double the total working width of the ploughshares during the period that the plough is being pulled towards the winding wagon. This forward movement takes place automatically during the winding of the cable on the drum without it being necessary to raise the flanges out of the ground or to lower them again, and without being obliged to reverse any gear. No skilled labour should, therefore, be necessary to supervise the anchorage wagon, and the distance it has to be moved forward is always adjusted beforehand to suit the effective width of the reversible plough and the length of the furrow.

Four workers should be sufficient to attend to an entire single winder ploughing set, *viz.* a winder wagon driver, a reversible plough driver, an ordinary labourer to help the latter, and one for the anchorage wagon. The surface capacity of the Single Winder Plough depends entirely on the capacity of the motor, the number, width and shape of the shares on the reversible plough, the depth of the furrow, the condition of the ground and the weather, and, not least, on the skill of manipulation. On an average, with a depth of furrow of from 15–35 cm. from 1·25 to 1·85 acres can be ploughed per hour, and the power necessary varies from 12 kw. hours per $\frac{2}{3}$ of an acre for surface ploughing in light soil, to 18–23 kw. hours for deep ploughing in heavy soil. It is not possible to give accurate costs of electric ploughing, as the working conditions vary so much and the power is also dependent on the working conditions, such as, for instance, whether ploughing deep or surface, with or without sub-soil looseners, etc. The advantages of the single winder ploughing system are as follows :—

(1) The extremely simple use of the plough set by four men; (2) the great stability of the anchorage wagon; (3) the easy transportability of the separate parts of the plough set; (4) the great surface capacity with a minimum consumption of current; (5) the possibility of a change of speed during the working by means of carefully and conveniently arranged gear-changing apparatus.

Whether preference be given to this single winder or to the double winder ploughing system depends on the particular circumstances and, consequently, can only be decided by considering the requirements of each particular case. For this reason it is usual to elicit from the farmer by means of an exhaustive questionnaire full details of the estate or farm, such as location, condition of soil (clay, sand, light or heavy, stony, roots, etc.), flat or hilly land, what grain or vegetables are most cultivated,

frequency of ditches, maximum depth of ploughing required, and whether there are other implements to be moved at the same time.

It may be said that even if the single winder system were, on the basis of its lower cost of construction and the cheaper cable network required, to be chosen, the double winder system is preferable where the ground is so loose that the discs of the anchorage wagon cannot find sufficient hold, or where the ground, on the other hand, is so hard and firm that the discs cannot force their way into it. It is also to be preferred for other field work where the attached wire of the single winder system would be in the way, as would be the case, for instance, in potato-gathering machines, certain types of plough, etc.; or where, on large estates, importance is attached to obtaining particularly large outputs.

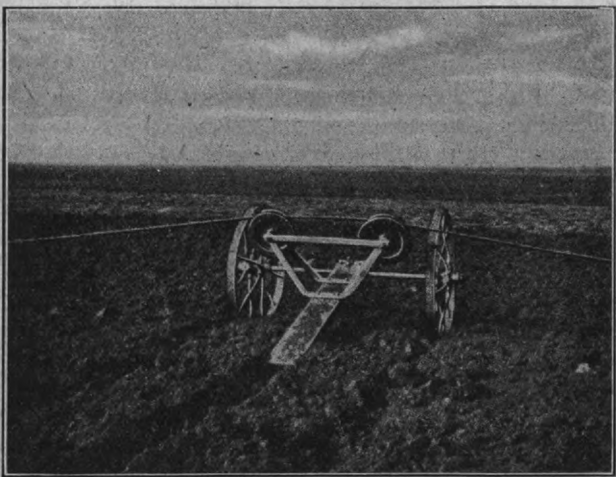


FIG. 13.—ELECTRIC PLOUGHING ON THE SINGLE WINDER SYSTEM, SHOWING CABLE GUIDING CARRIAGE.

(c) The haulage cable used for both the double winder and single winder systems is of special steel wire (Tiegel steel wire patent) of high tensile strength. The ends of the cable to be attached to the farming implements are provided with fasteners constructed so as to prevent the fraying of the wire cable and to prevent its becoming entangled.

In the single winder ploughing system two guide rollers are provided on a bracket arm attached to one side of the ploughing implements, etc., to give support to the looped or non-working length of cable, and a special cable guiding carriage (Fig. 13) may, in addition, be supplied for supporting this cable in special cases.

The following particulars of pre-war costs of complete equipments—(a) on the single winder wagon system, (b) on the double winder wagon system—may be of interest.

(a) *Single Winder Ploughing*, complete equipment, consisting of one transformer wagon with 75 kva. transformer 10,000 to 1,100 volts, with choking coils, switchgear, watthour-meter, etc., designed for a continuous load. One winding wagon, including one 75 h.p. 1,100 volt, 975 revolution three-phase motor, for a continuous load, with controller and switchgear, designed for a maximum pull of 4,000 kgms.; cable speed, 1·6 to 1·1 metres per second; wagon speed, 1·4 to 2·1 kilometres per hour, with accessories. One anchor wagon; 600 metres of 1,100 volt special flexible cable; one triple pole switch for transmission pole. Price, complete, excluding plough, £1,550.

(b) *Double Winder Ploughing*, complete equipment, consisting of two transformer wagons, each with 75 kva. transformers, 10,000 to 750 volts, with choking coils, switchgear, watthour-meter, oil, etc., designed for an intermittent load. Two winding wagons, including two 75 h.p. 750 volt, 730 revolution three-phase motors, for intermittent load, with controllers and switchgear, each wagon designed for a maximum pull of 4,000 kgms.; cable speed, 1·6 to ·9 metres per second; wagon speed, 1·4 kilometres per hour. 600 metres of 750 volt flexible cable; one triple pole switch for transmission pole. Price, complete, excluding plough, £2,000.

The only electric ploughing installation in this country* of which the author is aware was one carried out on a farm of 240 acres belonging to Mr. Chorlton, near Cotgrave, some eight or nine miles from Nottingham, by Messrs. E. O. Walker & Co., of Manchester. The soil was of heavy clay, which would be very difficult to plough by other than mechanical means.

Threshing.—The driving of threshing machines formed one of the earliest applications of electricity in agriculture. With the exception of electric ploughing, as regards motor capacity and power consumption, electric threshing occupies the highest place in purely agricultural

* Vide *Electrical Review*, January 19th, 1916.

work, and for this purpose motor wagons are largely used, as well as motor trucks, and motor sledges.

With the building of long-distance central stations the application of the electric motor to threshing machinery has continued to increase, and it may be said that no farmer who has once tried electric threshing wishes to dispense with it if electric current continues to be at his disposal.

Threshing in the field furnishes, also, one of the most important uses of the portable transformer in connection with agriculture. When a greater output is necessary, and when the distance of the work from the farmyard and, therefore, from the fixed transformer which supplies current for lighting and power is too great, the portable transformer finds a useful opening, and indeed it may be said that electric threshing plants obtain their full freedom of movement only when such a transformer is available. For this reason many threshing associations in Germany include a portable transformer in their threshing plant equipments, and thus open up the way for the general introduction of electric threshing throughout the country. The employment of a portable transformer enables the farmer to do his threshing at any desired place in the neighbourhood of an overhead high-tension line. He thus saves time, as well as horses and workers, and avoids the wastage in carrying the corn for threshing to the yard, and afterwards removing the straw.

With regard to the actual application of the motors to threshing, reference may be made to Fig. 1, where a motor wagon is shown belted to a threshing machine in the field, the current being supplied through portable transformers from an overhead line. In some cases the threshing machine is provided with a "built-on" motor, and in this case, of course, the motor travels with the threshing machine and is not available for driving other machines.

The power taken for threshing depends upon the moisture present and the lengths of stalk. The following table based on actual measurements may be taken as reasonably reliable—

	Kilowatt hours per cwt.
Rye	0·35 to 0·70
Wheat	0·35 ,, 0·60
Oats	0·25 ,, 0·50
Barley	0·30 ,, 0·55
Mixed grain	0·28 ,, 0·45

The horse-power of the motors required varies from 2 to 6 for threshing machines formerly worked by hand or by haulage animals.

Motors of 20–25 h.p. are used for larger machines with straw presses, and these have a current consumption of 10–12 kilowatts per hour and an output of 20-30 cwt. of threshed corn.

The horse-power required for a given farm can be easily calculated from the number of acres, an estimate of the corn produced per acre, and the table given above for the units required per cwt.

The following particulars, which are largely based on letters from farmers and reports from public bodies, give some of the advantages of electric driving particularly in connection with threshing:—

(1) Low first cost and working costs as compared with steam threshing, especially when the horse-power required is small or the working periods short, and particularly, of course, where a cheap supply of current can be obtained. The saving in energy and expense with the electric motor is shown by the fact that it can be stopped for short periods between work, when coal would have to be consumed in a steam traction engine to maintain steam.

(2) The special preparation, such as the heating of the boiler in locomotives, the procuring of water, coal, etc., is not necessary with electric driving.

(3) The motor is of small weight, occupies little space, and is, consequently, very portable and available for use at any particular place where it may be required.

(4) The motor is adaptable to varied working conditions, for example, to change of weather, as during the rain when the farm hands cannot work in the fields outside they can be withdrawn for the threshing, which it is understood in this case is carried on in the barn.

(5) The simplicity of the control arrangements of the electric motor which are operated by the movement of a handle, handwheel, or something similar.

(6) The fact that the efficiency of the motor is independent of its age. An electric motor also works at high efficiency even when the load it is taking is not as high as it is designed to take. This is not the case with steam driving, which practically consumes the same quantity of coal at light load, when driving very little, as it does on full load.

(7) Great security against fire, and freedom from any danger of explosion.

(8) The uniformity of rotation on the electric motor gives a cleaner threshing, consequently a smaller waste of current, and also a greater

output in comparison with other kinds of driving.

It has been shown by repeated measurements that the saleable corn resulting from electric drive amounts to from 1–1½ per cent. more than with the usual steam or other drive employed, due to the more uniform turning moment of the electric motor.

It may also be added that there is no danger incurred by bringing the electric motor close to the fences or sheds, which is not the case with the steam locomotive, petrol engine, or gas engine, as the motor is fully enclosed, and in the larger sizes is carried with all its accessories in a small completely locked wagon, which allows of easy transport and permits the motor to be placed as near as may be to fences, etc., and in any position in the sheds or yard. It can be placed in the barn itself, if necessary.

In reply to a question when giving evidence before the Canadian Committee on Agriculture and Colonisation,* a witness said, when referring to electric driving: "You get a better quality of chaff, it absorbs the moisture from the grain when it is kept for a longer period before threshing; then again, your grain is a better product from leaving it longer in the head. In 1912, three-fourths of the grain in the country was heated because it was threshed too soon, and most of it was harvested wet."

The cost of an equipment for electric threshing depends, of course, on the size of the threshing machine to be given, and on the accessories necessary. An approximate idea of the cost of the necessary motor wagon may be obtained from the figures already given: thus a motor wagon of 34 h.p. capacity, with accessories, should cost before the war approximately 2,500 marks, and allowing 500 marks for the part cost of electrical conductors, etc., they would give a total first cost of 3,000 marks exclusive of the cost of the transformer wagon if such were needed. The cost of this would, in any case, in part, have to be charged to other work.

General.—For operations on the farm other than ploughing and threshing, portable motors of the type already described are generally employed. Stationary motors are also used where the work is of a more continuous nature. An illustration of a permanent motor driving a model dairy in Canada is given in Fig. 14, the electricity in this case being supplied from the

* Report of Select Standing Committee on Agriculture and Colonisation, Canada. App. No. 2, 1914.

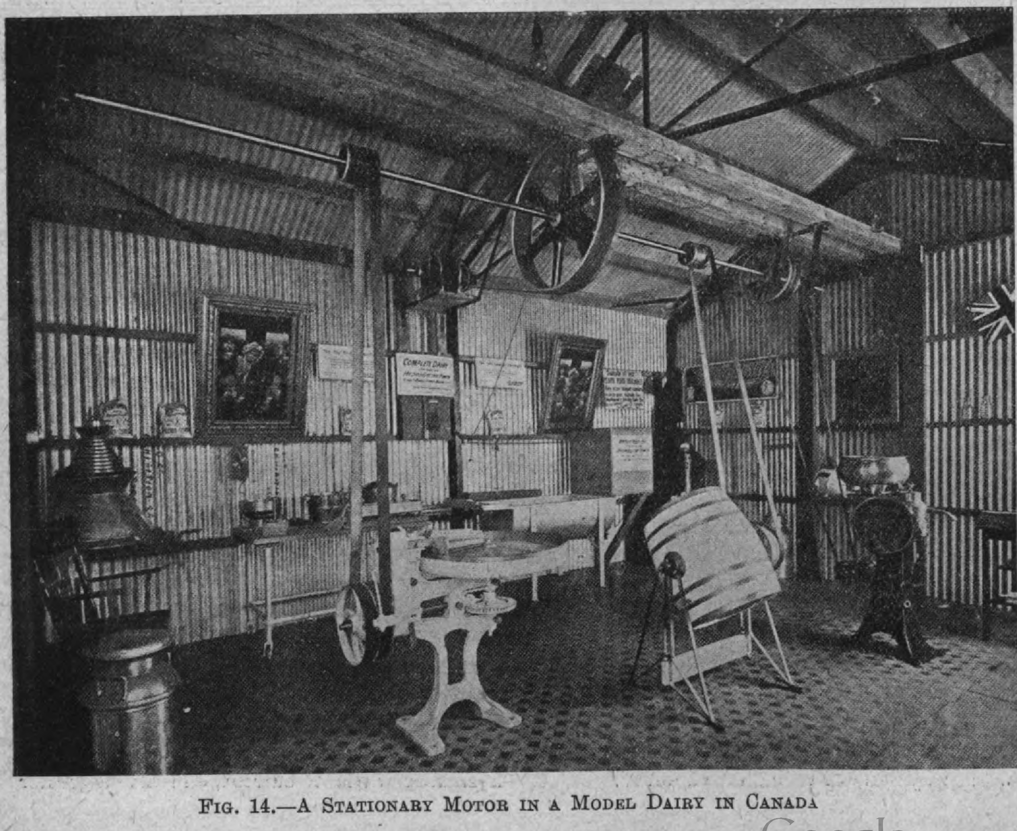


FIG. 14.—A STATIONARY MOTOR IN A MODEL DAIRY IN CANADA

mains of the Ontario Hydro-Electric Commission.

The following figures for power consumption on certain farming operations based on tests give some indication of the costs of performing these operations by electricity:—

Chaff Cutting.—A motor of from 2–5 h.p. will cut in an hour up to 20 cwt. of chaff with a current consumption of 0·1 to 0·3 kw. hours per cwt.

For purposes of comparison it may be said that it usually takes one man one hour to cut 1 cwt. of chaff, while two horses and a driver are capable of cutting 3 to 4 cwt. per hour.

Turnip Cutting.—The current consumption for this work varies from 0·01 to 0·02 kw. hours per cwt.

Oat Crushing.—The current consumption for oat crushing is about 0·25 kw. hours per cwt.

Milk Separating.—A motor of 1 h.p. can deal with an output of 2,100 litres per hour with a current consumption for skimming, churning, and kneading the butter of 0·25 units per 100 litres.

In forming an idea of the probable cost of current to be consumed by a motor of given size on farm work, it should be remembered that an agricultural load is a very fluctuating one, and for general purposes it is usual to assume that a motor is on full load only during one-third of the working time, and that during the remaining two-thirds of the working time it is only on half load, and it is found in practice that working on this basis gives a fairly good idea of the probable consumption.

In making a comparison between the working cost of driving by electric motor and by heat engines, in addition to the expenditure in coal, petrol, electric current, etc., allowance should be made for interest, depreciation, maintenance, lubrication, and attention, and if these factors are taken into account it will generally be found that with the smaller motors up to, say, 20 h.p. electrical driving is cheaper than any other form of driving with current at the usual rates obtainable in country districts, whereas for outputs of above 20 h.p. the running costs of other forms of power begin to be competitive if the cost of electricity is excessive, particularly if the machines are in continuous service. The low first cost of electrical plant and the discontinuous service required for motive power in farm work are, however, very much in favour of electrical driving.

The following table gives approximate pre-war costs of the motor cradles, trucks, motor sledges and motor wagons already described:—

Motor cradles up to 3 h.p., including 15 metres of flexible cable—without gear reduction	240–550 marks.
Ditto with gear reduction	350–700 marks.
Motor trucks or sledges from 2 to 6 h.p., including 20 metres of flexible cable . .	900–950 marks.
Motor wagons from 10 to 12 h.p., including 20 metres of flexible cable	1,400–1,500 marks.
Ditto for 21 to 30 h.p. .	2,200–2,400 marks.
Ditto for 40 to 55 h.p. .	2,900–3,550 marks.

Conclusion.

The following abstracts from a recent important report* should show that German agriculturists had faith in the claims they made for electric power and lighting on the farm. The writer states that "the use of electric light and power has spread with striking rapidity in the agricultural districts of Germany in recent years." And he adds the further statement that in "Saxony electricity was used to a far greater extent by small and medium holders than by large holders."

The most striking lesson we can draw, however, from a study of the application of electricity to agriculture in Germany lies in the manner in which the thinly-populated rural districts secured the advantages of a cheap supply of electricity. This was done in the main through rural co-operative societies, and the growth of these societies in recent years reads almost like a romance. In 1901 there was one such society; in 1909, 82; on January 1st, 1910, 257; on January 1st, 1911, about 340; and in 1913 the number had increased to between 600 and 700, or more than the total number of public electricity supply undertakings in the United Kingdom.

Some of these societies produced electricity themselves; some bought electricity in bulk, and distributed it over their own distribution system; while others still only combined to guarantee a certain consumption, and thus secure cheap current from the supply authority.

It is worthy of note that in remote districts where the erection of a central station might not be justified, the societies sometimes purchase surplus power from private undertakings which manufacture electricity for their own use.

In this country, which is comparatively

* Report to Board of Agriculture and Fisheries, by J. H. Cahell. 1913.

thickly populated, and where the distances to be traversed are not so great, the provision of electricity in rural districts is a much simpler undertaking than its provision in the rural districts of Germany, and the author feels that if steps were taken to promote a co-operative movement in this country for the supply of electricity in these districts, considerable progress would be made.

There are over 428,000 farms of from 5 to 300 acres each, and averaging 60 acres, in the United Kingdom, and it is estimated that to operate these electrically would consume not less than 4,000,000,000 units per annum, or as much as is generated altogether by the whole of the electricity supply undertakings of England and Wales. This in itself is a striking fact, and indicates to some extent the importance of this load from the point of view of the supply authorities.

Apart altogether from the question of electricity supplies, much has been achieved in many districts in Germany by combination among the farmers, and the interests especially of the small and moderate landowners have been substantially advanced by means of the co-operative system. In these countries co-operation might even go further than in Germany, and provide the portable electrical apparatus necessary for use at the farm, this being passed on from farm to farm as the work is completed, as is at present done with threshing machines. A considerable future should lie in front of co-operative endeavour of this character.

The problem is of interest, too, to the manufacturer of electrical machines, and unless some steps are taken to meet the growing demand for machines designed for the technical conditions of agricultural work, this country will lose a good deal of this type of business abroad. In the Argentine, Australia, Canada, and Russia, not to mention China, there are many millions of acres that will need cultivation and transport facilities in the immediate future, and the provision of the necessary equipment is work one would like to see done here. In this connection we may recall the very considerable assistance the Royal Agricultural Society gave in the development of the steam plough, and also in the development of the internal-combustion engine, particularly through the trials held at the Society's shows and the valuable prizes offered for the best designs of apparatus.

It would not be easy to over-estimate the help similar trials and prizes for the best design of portable electric transformer wagons, portable cable creels, portable motors, etc., would give in the development of electricity applied to agriculture, and it is to be hoped the Society may see its way to do something in this direction.

Demonstration wagons also, such as that illustrated in Fig. 15, which is one of two wagons sent into rural districts by the Hydro-Electric Commission of Ontario to illustrate "the use of electric power in the household and its application to the driving of farm machinery," would do much to familiarise the farmer with electric driving and its advantages.

As showing the relative positions of German and British agriculture before the war, the following may be quoted from a recent memorandum.* On each hundred acres of cultivated land:—

(1) The British farmer feeds from 40 to 50 persons, the German farmer feeds from 70 to 75 persons.

(2) The British farmer grows 15 tons of corn, the German farmer grows 33 tons.

(3) The British farmer grows 11 tons of potatoes, the German farmer grows 55 tons.

(4) The British farmer produces 4 tons of meat, the German farmer produces 4¼ tons.

(5) The British farmer produces 17½ tons of milk, the German farmer produces 28 tons.

(6) The British farmer produces a negligible quantity of sugar, the German farmer produces 2¾ tons.

Many causes contributed towards the superiority of the German agriculturist, first among which must be placed the increase in the use of artificial fertilisers, which rose between 1890 and 1910 from 1,600,000 to 6,000,000 metric tons. Some credit must, however, be given to the increased use by the farmer of the mechanical aids to husbandry, to some of which it has been the object of this paper to draw attention.

It was stated in a recent publication † that "food shortage, greater production, scarcity of labour, increased efficiency, freight congestion, priority of shipment, high prices, and economy in delivery . . . are a few of the things that will compel the farmer to turn to mechanical power." A study of the application of electricity to farm work in Germany seems to the author to show that the farmer in this country will be wise if he carefully considers the claims of electricity

* "The Recent Development of German Agriculture," by T. H. Middleton, C.B., 1917. (Cd. 8305.)

† The *Vulcan* (New York), Vol. I, No. 3, November, 1917.

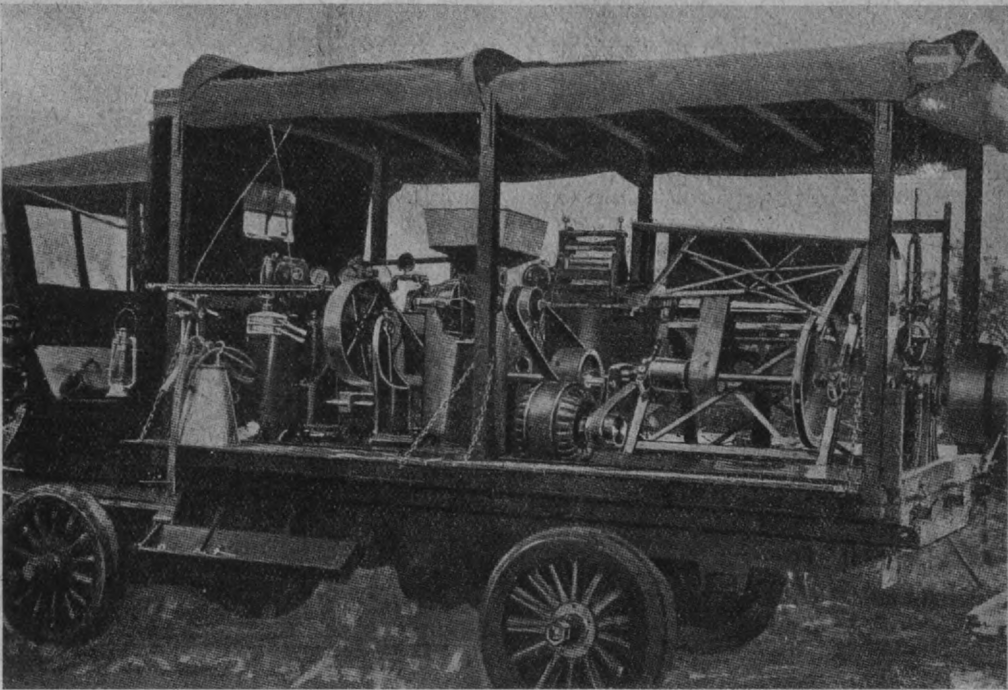


FIG. 15.—ELECTRICITY APPLIED TO AGRICULTURE IN CANADA.
DEMONSTRATION LORRY: FROM LEFT TO RIGHT, CREAM SEPARATOR, MILKING MACHINE, GRINDER, AND CIRCULAR SAW.

before he adopts other methods for providing the mechanical power he will undoubtedly need in the future.

The writer wishes to acknowledge his indebtedness to Mr. A. M. Morrison, B.Sc., for considerable assistance in the preparation of the description of the machines in use in Germany, and to Messrs. Siemens Brothers Dynamo Works for placing the technical information in their possession at his disposal.

DISCUSSION.

THE CHAIRMAN (Sir William Barrett, F.R.S.), in opening the discussion, said he had listened that afternoon to a most interesting, practical, important and lucid paper. The author had had the great advantage of being connected for many years with the great firm of Siemens as one of its foremost members, and therefore had had an unusual opportunity of seeing what electricity had done in Germany, and the many directions in which it had been applied there. Germany had taught us many things, as we knew to our cost, and not the least had been the great part that science played in the education of all classes throughout Germany, and the very small part it had hitherto played in our education in the British Isles. We had begun at the wrong end. Instead of starting above and working downward we had tried to force our science from below upwards, by establishing technical schools for workmen throughout the country. It was not until employers recognised the extreme value of all applications of science, and especially of electricity, in their different forms of industry, that they would be found selecting skilled men and finding the value of the men who had been trained in our technical schools. The audience had had that afternoon a striking and comprehensive view of how electricity had been used in agriculture, not only for the purpose of lighting but of power and of transport, and in various other mechanical ways. Some of the facts and statistics which Dr. Crowley had given were new and were of extreme value. They made one ashamed of how little had been done in this country and especially in Ireland, of which country the author was so brilliant a son. He might remind the author that seventy years ago Sir Robert Kane, in his "Industrial Resources of Ireland," had pointed out how much Ireland could contribute to the industries of the United Kingdom if only its available natural sources of power were utilised, especially its water-power, *e.g.* at Killaloe. There was a source of water-power which probably could be made use of, and to which he (the Chairman) had drawn attention in 1901 in his inaugural address to the Irish Electrical Engineers.

Water in our towns and cities was used for drinking and cleansing purposes, but not for its power. Water distributed through mains possessed energy as well as matter. In the excellent water-supply of Dublin a system of lowering reservoirs was used to reduce the pressure of the water from its original source down to the pressure at which the pipes would carry it for distribution throughout Dublin. In all of those successive and numerous reservoirs, the water poured in in an endless stream, and the power was entirely wasted. Why should it not be utilised? In his address he had given the amount of power that could be obtained in Dublin alone in that way. The most important fact which the author had brought out was perhaps that as labour went on increasing in price and became therefore more difficult and costly to obtain, electricity would become a more and more important factor, not only in economising labour, but in extending the hours of labour by its use at night. One aspect of the problem had only been casually alluded to by the author, namely, the use of electricity in stimulating the growth of seeds and accelerating the growth of plants. About twenty-five years ago an ingenious Irishman had come to him (the Chairman) about the matter. The man had erected a number of wires across a portion of his arable land, and had connected them with tall poles, and he had found the crops had increased in that portion of the field more than in other portions, and he had thought this had been due to electricity. He (the Chairman) had repeated the experiment on ground of his own, one controlled plot being used without wires and another plot with wires. He did not use any artificial sources of electricity, and both plots were planted with potatoes and manured in exactly the same manner. Curiously enough he did find over two or three years a 20 per cent. increase of potatoes was grown on the wire-covered plot as compared with the plot that was not so covered. That result had been confirmed by other experiments, although some years had been very much better than other years. Sir Oliver Lodge's experiments had tended to show that the direct application of electricity to the growth of crops did really increase the output.

Mr. F. S. Courtney (Consulting Engineer to the Royal Agricultural Society) remarked that perhaps the most useful point about the paper, or at all events that which would appeal most to the agriculturist, was the statistics given of the rapid increase in the application of electricity to agriculture in Germany. He (the speaker) was quite sure that the English farmer was not at all apathetic or slow to move in the adoption of any machinery once he was perfectly satisfied that he was going to benefit by it. The farmers had given up their steam engines readily and willingly the moment they had been convinced that the internal-combustion engine was a more convenient and economical proposition under given conditions for very intermittent work, and the farmer would do the same with his combustion engine the moment electricity was available. What must be looked forward to was the development of electricity from the big central stations at the coal producing centres. There were some cases where a man might advantageously generate his own electricity, especially where there was water-power; but the agriculturist would not put down a plant himself to generate his electricity. He could not do it at a remunerative price, and he had not the staff with which to do it. He had to look to a generating station. With water-power, of course, it was a different matter. On that question, no doubt there was ample opportunity in this country to utilise a very large number of powers. There were many old disused flour-mills absolutely doing no good at all. He could give an instance of one of them, which a friend of his had bought. His friend wanted to know if he could put him in the way of finding a new tenant for his mill. He had told his friend at once that such mills were of no use to anybody; that the corn all went to the larger mills. He had advised his friend to instal an electric light plant in the mill. This advice was followed, and the plant had been running for about fifteen years. There was about 30 h.p. there. His friend ran about six hundred lights; he had got a herd on the home farm of ninety-seven head of cattle; he did all his chaff-cutting, all his food preparation, his saw benching, the pumping of the water for the estate, and he also had a fire engine centrifugal pump which gave a couple of hundred feet pressure whenever wanted by the mere turning on of a switch. One of the most useful adaptations in the country for country houses, where there was an electric light installation, was to have a high pressure centrifugal pump, because the pressure could not be increased beyond a certain point that the pump was built for, and the pressure was available by the mere turning on of a switch. Referring to the question of ploughing by electrically-worked machines, he trusted that those who were studying that point would not forget the history of the Fowler double-plough system. In 1871, when he (the speaker) had been at work on the trials of steam ploughing gear at Stafford and Wolverhampton, the roundabout system had been in competition there. For the smaller farmers it certainly looked a very promising system. What had become of those roundabouts? Very few of them were seen now. He had been talking last year to one of the makers of those roundabout systems, and had asked him what had become of them. The maker informed him that, having a roundabout set and a double-engine set of ploughing tackle, which he used to hire out, working in the same parish, he had found that on starting on the same day the double set got about eighteen acres start of the roundabout; it had taken that time to get the tackle fixed and started, and consequently he abandoned the system. He knew a friend who had bought a double set of

tackle after the Wolverhampton trials, and they were at work now, and when he had inquired last year what they were doing, he had been informed that fortunately just before the war his friend had sent his two engines back to the makers to have new boilers, and this time last year his friend had said that the engine was working just as well then as it was when it was brand new. That was a life which could not be expected from the present-day tractor. The electric motor for ploughing had a very great advantage over any reciprocating engine. There were no reversals of strains. There was a rotary motion; one got straight away on to the drums, and the work was very much steadier and more uniform. It was also very much easier to design a good electric winch than a really smooth working reciprocating engine set. For intermittent work, of course, electric power would have a very great advantage, and the value of electric lighting on a farm was a very important matter, but one had to be careful to have special fittings for lighting in farm buildings, especially in stables, because with ordinary fittings the ammonia would cut them to pieces in a short time.

Mr. J. S. Dow thought that the application of electricity to agriculture on a large scale was essentially a matter of transmission of energy; it would remain limited so long as farmers had to generate their own supply, and on the small farms in this country the expense of such individual effort was a serious item. It was necessary, therefore, to plan out the distribution of energy with courage and foresight, as had been done in Germany and the United States, in the expectation that eventually a paying load would be secured. It must also be remembered that most agricultural operations were intermittent. Small farms might not be able to afford the cost of the electric windlass system of breaking up new ground, but there was no reason why such machines should not be loaned out to a number of farms, if electric supply was generally available, and connections could be made through mobile transformer-waggons, as Dr. Crowley had explained. He believed it was accepted on the Continent that really deep ploughing on stiff ground could not be achieved by a tractor which had both to break the ground and propel itself. Hence the advantage of the electric windlass systems, which seemed little known in this country. The machines of German design were powerful but heavy; in the French type an attempt had been made to secure less weight and greater mobility, a very important factor. Dr. Crowley had only referred incidentally to direct electro-culture. Promising experiments had been made in this country, and he would like to know what results had been achieved abroad. High tension discharges for such work could surely best be dealt with by centrally generated power distributed over a large area, instead of each field or fields being treated by the individual farmer. Once electrical supply was available agricultural loads could be combined with other special local operations, such as peat-extraction. Electric transport was almost as important to the farmer as electric light and power. In the south-western district of Ireland he had been struck by the small number of farms and the few people employed; often by far the greater number of a family had emigrated. This was popularly ascribed to the fact that the soil was poor and the farms would not support a large family. He was inclined to think, however, that if better facilities for bringing products to market were available in such remote regions agricultural operations would be pursued with greater vigour and the output would be greatly increased.

Mr. D. J. Williams remarked that all were agreed that any step taken towards increasing the production of food at home was of national importance, and no doubt the more extensive use of electricity in agriculture was a step in that direction. It was difficult to predict the future prospects of agriculture, as after the Napoleonic wars there was great depression in this country, while on the other hand a period of prosperity followed the Crimean War. Agriculture had been allowed before the war to drift into a most unsatisfactory condition as far as this country was concerned, and some steps would have to be taken to regenerate it. The price of land had been steadily on the increase, labour was scarce, and wages were high, and the prices of feeding-stuffs and artificial manures were abnormally high, and though the farmers' gross receipts were substantially increased during the war it was questionable whether the average farmer was better off financially, and a good number were perhaps worse off than in an average year before the war. He considered that the author's paper was most timely, as showing the extent to which electricity had been applied in Germany, where the subject had been studied with great thoroughness. The author had mentioned big central stations to supply power to farmers, but it might be some years before those central stations would come into being. In many parts of the country, however—for instance, in Wales—small water-power schemes could be economically developed for agricultural purposes. The United States Geological Survey Engineers had made an estimate of the waterfalls capable of developing 1,000 h.p. and upwards which were unused in that country, and came to the conclusion that a minimum of 30,000,000 h.p. could be developed for four months in the year and double that power for the other eight months. It was not, however, the 1,000 h.p units that he (the speaker) had in mind, but the small streams and rivers all over the country that were at present going to waste, and which ought to be harnessed for the use of the farmer and the public generally. Very little power was required to supply the homestead with clean, cool and safe

light in place of the dangerous oil lamps and candles in common use, as the author pointed out. Less than 1 h.p. of energy would light the homestead; less than 5 h.p. would provide light and small power. Every 4,000 gallons of water that fell one foot in one minute, or 400 gallons that fell ten feet in one minnte, or forty gallons that fell 100 feet in one minute, meant 1 h.p. When it was realised that 250 cubic feet of water a minute falling ten feet would supply the average farm with light, heat and small power, the possibilities were enormous. There were several installations in North Wales averaging some 3·5 h.p. used for farm lighting. Another aspect of the matter was the question of the stimulation of plants by electricity, either by direct action on the plant or by indirect action in the soil. That had long been a favourite field of investigation, and it was on record that as far back as 1783 the Abbé Berthelon carried out some experiments in that direction. There were several investigators studying the problem at present, and the results were awaited with much interest.

The Author, in reply, said he found himself very much in agreement with the remarks of Mr. Courtney, who had referred to the fact that the farmer of this country was enterprising when he was satisfied that he had got a good article. With that all must agree, because one must feel that after all what a body like the Royal Agricultural Society did was but an expression of the mind, etc., of the farmers themselves. There could not be an enterprising Royal Agricultural Society if there was not enterprise among the farmers. The steam plough got a very fair trial from farmers, and the internal-combustion engine was taken to very readily; and he had no doubt that if the condition mentioned by Mr. Courtney was fulfilled, namely, that electricity should be made available in the rural districts, farmers would use it. The real problem, therefore, was the provision of that electricity, and he hoped, under the new Electricity Bill, which would make provision for big stations, a great development in that direction would be seen. But he still believed that in the co-operative movement among the farmers themselves was the real solution, because they were the people primarily interested, and if they took steps to act co-operatively somebody would be enterprising enough to provide the electricity. He thought water-power ought to be developed; but he felt that it would be difficult to induce the farmer to develop small plants, and that it would be much easier to induce him to put down motors if the electricity supply were available. He also agreed with regard to the advantages of rotary motion as against reciprocal. The universal experience in Germany had been that there was a greater production of material from threshing machines with electric driving—that was, rotary motion—than there was with reciprocating driving by steam. Mr. Williams's remarks had been of great interest, and that gentleman's experience in North Wales clearly showed that small powers could be economically developed in rural districts, and if the farmers would develop them, they would be of great help.

On the motion of the Chairman, a vote of thanks was accorded to the author for his interesting paper.

FETA CHEESE INDUSTRY.

Grecian cheese in brine, commercially known as Feta or Fetta cheese, is manufactured in the Athens district, under circumstances so simple and surroundings so primitive as almost to debar it from a place as a manufactured article, since it is almost a natural product. It is made by shepherds scattered over the mountainous portion of Greece, each man preparing the cheese in his tiny hut in accordance with his habits.

The process of preparation is essentially the same throughout the district. The milk, generally sheep's milk, is poured into large receptacles and slowly heated, if necessary, to bring it to a temperature approximating body heat, in order that fermentation may take place advantageously. Rennet is then added to the milk, and when properly curdled the whey is decanted and the curds wrapped in cheesecloth woven from wool. The mass is slowly pressed by twisting the empty upper part of the bag until all free whey is squeezed out, when the bag is hung up to drip for a period of ten to twenty-four hours, depending, naturally, upon the humidity of the atmosphere and the speed of evaporation in conjunction with the pressure exerted by the weight of the mass.

At the end of this period the solid mass of casein is unwrapped and sliced, and dry salt is liberally sprinkled over the slices. At this stage of the process an interesting exchange takes place. Because of its hygroscopic properties the salt absorbs much of the moisture still left in the curds, and the saline solution is then quickly absorbed by the cheese on account of the greater valence of the salt solution than that of the fresh water which previously permeated the pores of the curds.

This salting process is generally completed within twenty-four hours, and the cheese is then ready to be packed in wooden barrels holding from 112 to 169 lb. After four or five days' "ripening" the cheese is ready for eating. Its taste from this point until it begins to deteriorate is not unlike Devonshire curds if salt and a little cayenne pepper be substituted for the sugar and cream with which that familiar product is most frequently eaten.

A by-product is frequently made from the whey extracted in the process described above. The shepherd pours the whey into fresh milk, which undergoes a course of curdling slightly different from the original process, because of the lactic-acid bacteria that are now present in the whey, in

addition to the undigested rennet ferment left in the liquid. The milk remains in vats for four or five days, after which the whey is removed and the residual casein is disposed of fresh as "pot cheese" or "Mitzithra," and is largely consumed by Greek colonies abroad, as well as being much favoured in the district.

According to a report by the United States Consul-General at Athens, from which the foregoing particulars of the industry are taken, no written contracts are made between the merchants and the shepherds. The merchant interviews the shepherds with whom he deals and arranges to take over all the cheese produced at an agreed price or at the prevailing market price. If the shepherd is in need an occasional advance is made to him, based on a minimum price and a certain portion of the amount of cheese which the shepherd may be expected to make. Sometimes this advance may be as much as 20 to 30 per cent. of the estimated value of the cheese to be delivered, but more often than not no advance is made and the agreement is merely a verbal one. It would be manifestly impossible for the shepherd to know in advance just how much cheese he will make, as many contributory factors play highly important parts in controlling the output, among which may be mentioned weather, rainfall, epidemics among the sheep, and many other contingencies impossible to foresee.

Feta cheese is purchased for export under substantially the same conditions as obtain when it is bought for local consumption, although the exported article is probably more free from contamination than that bought in small quantities from a native food-shop. When the article is sold from the barrel it has a tendency to deteriorate, and loses from 25 to 40 per cent. in weight on account of loss of moisture by evaporation. Again, the local consumer secures a relatively immature cheese, as it is frequently sold and eaten in Greece within three days after salting, whereas, if properly packed for export and kept in cold storage, the quality and flavour are thought by some connoisseurs to be perhaps a trifle superior to the strictly fresh article exposed for sale in the local markets.

The basis of value of cheese sold locally is, of course, the quality, and this is determined by its appeal to the palate. Certain factors, however, are taken into consideration in fixing prices, among which may be mentioned the richness, or fat content, of the cheese; the quality of milk from which it is prepared (sheep's milk is considered to be much superior to goat's milk); the time of year in which the cheese is prepared, since milk collected in summer has a better flavour than winter milk, on account of the meadow grasses and herbs eaten by the sheep or goats; and, finally, that elusive something which makes one brand of an article better than another, although prepared from approximately the same materials and under substantially similar conditions. Feta cheese made of sheep's milk sells for prices ranging around 8½*d.* per lb., while the product made from goat's milk may be had for about 5½*d.* per lb.

Cheese made from sheep's milk is ivory white, while goat's-milk cheese is flat, white and rather chalky in appearance. Sporadic attempts are made from time to time to counterfeit sheep's-milk cheese by tinting the goat product with butter colouring or other materials, but the taste of the product is different, and the fraud is quickly detected.

It would not seem that the value of the cheese is affected by the amount of brine contained therein, or by the time that the cheese has been allowed to dry, within reasonable limits. Of course, it should be understood that cheese manifestly having too little or too much brine, or spoiled by having become too dry, would be worth less than the same product in proper condition, as with any other article of food. Feta cheese, when improperly packed, dries out, becomes red and very salty, and so loses flavour and digestibility.

NOTES ON BOOKS.

JOHN THOMSON OF DUDDINGTON. By Robert W. Napier. Edinburgh: Oliver & Boyd. 31*s.* 6*d.*

The admirers of Thomson of Duddington will be grateful to Mr. Napier for the loving care which he has devoted to the preparation of this very handsome volume. It gives an excellent account of the artist's work, not the least valuable part of which is a descriptive catalogue of his pictures, covering over 130 pages, and a bibliography. The second section contains what is probably the fullest account in existence of Thomson's life, and reveals a very charming and wholly lovable personality.

Mr. Napier is at great—perhaps too great—pains to defend Thomson from the charge of amateurishness which has sometimes been brought against him. Thomson was, of course, a clergyman; but his ministerial duties seem to have sat lightly upon him. As a rule he only devoted Saturday and Sunday to them—sometimes not even these. His congregation at Duddington, a beautiful suburb of Edinburgh, were eminently enlightened, and appreciated to the full the reflected glory which they enjoyed from their minister's artistic reputation. No obstacles were thrown in the way of his devotion to art. He seems to have enjoyed great liberty in the way of absenting himself from his charge for long periods, which he spent painting in the Highlands and elsewhere. So far from the responsibilities of his church interfering with his artistic work there, it would seem that his cloth provided him with an adequate livelihood and saved him from the necessity of "pot-boiling," while allowing him ample time to spend on his canvases. With regard to another aspect of the same criticism, it must be admitted that Thomson received no early and systematic training in art.

No doubt he realised the need of this himself, and he eagerly seized such rare opportunities as came his way to make good the deficiency; and it is probable that, despite Mr. Napier's not altogether undeserved jeers at the art schools of his time, if Thomson had received the preparation which circumstances denied to him, he would have gained an even greater mastery over his mediums than he possessed.

Thomson was an intense and indefatigable worker, and produced a large number of admirable landscapes. Some thirty of these are reproduced in Mr. Napier's volume, and give a fine impression of the artist's romantic imagination and dramatic power. He is particularly successful in depicting wild and rugged Highland scenery. It is greatly to be regretted that, owing to the defective materials which he used, especially asphaltum and megilp, many of his pictures are now in a very bad state of repair; but fortunately quite enough remain to show that he was easily the first Scottish landscape painter of his day.

Mr. Napier's book leaves one with a delightful impression of Thomson. Although he was driven into the church against his will, it finally provided him, as we have seen, with an easy means of living, while it did not interfere too seriously with his artistic work. His charming personality, as well as his great gifts, made him the friend of the best literary and artistic lights of his days. His intimate circle included such names as Sir Walter Scott, Sir Henry Raeburn, Sir David Wilkie, Sir David Brewster, and he was one of the very few who were able to keep on friendly terms with his great but difficult contemporary J. M. W. Turner. He was fortunate in securing public appreciation of his work at a comparatively early age. Although when he began painting he was in the habit of giving away his pictures with a lavish hand amongst his friends, he soon found them fetching reasonable prices, and for many years he made something like £1,800 per annum, which was considered a very large income for a landscape painter of those days. Altogether Thomson seems to have been a singularly fortunate and happy mortal, and Mr. Napier has compiled a volume that is a fitting memorial of the parson-painter.

GENERAL NOTES.

Vegetable Oils.—In the early months of this year, says the *Colonial Journal*, the imports of palm oil showed a substantial increase over those of 1918; but the striking feature was the large increase of cotton seed, which was nearly ten times the quantity imported in the same months of 1918. In spite of this, however, there was recently a shortage of materials, which can only be explained by a greater consumption. The British manufacture of margarine is now firmly established, which means that at least £10,000,000 a year, which would under the old conditions have gone abroad, is now kept at home. Popular taste greatly favours coco-nut butter, and the price of copra went up decidedly everywhere this spring. It is now about double the figure it stood at ten years ago, and as this commodity is the first thing that the enemy countries will buy on a big scale when they get the chance, it is more likely to rise than fall.

Peruvian Trade.—In view of the absence of economic news from Peru, considerable interest attaches to a statement given by the Peruvian Consul in Switzerland to the *Journal de Genève* and quoted in the *Economist*. The value of Peruvian imports in 1916 was £8,683,150; of the exports, £16,541,063; in 1917 the exports jumped up to £13,502,851, the exports to £18,643,414. The value both of imports and exports in 1917 was more than double that attained in 1913, and thrice that of twenty-five years ago. Agriculture has made great progress, and much machinery of the most recent types has been imported from the United States. Pedigree cattle have also been imported, while asses from Switzerland and Italy, brought in before the war, have sired a greatly improved breed of mules. Large quantities of petroleum were discovered in 1918 in the departments of Puno and Ayacucho, and are now being worked by a foreign company, while the rich deposits in the department of Piura are also being actively exploited. Tungsten mines, discovered in 1916 in the department of Cuzco, are also to be worked on a large scale, and it is alleged by experts that the Peruvian deposits of this metal are the largest in the world. The total value of all the products of mining in 1917 was not far short of £10,000,000.

Gas from Straw.—Attention is drawn in the "*Times*" *Trade Supplement* to a statement recently made by Dr. R. D. McLaurin, formerly Professor of Chemistry in Saskatchewan University, with reference to the enormous amount of potential power in the great amount of straw produced each year in Western Canada. Experiments originated by Mr. George Harrison, of Moose Jaw, have shown that a gas can be obtained in large quantities from straw, and that this gas can be utilised in the same way and for similar purposes as coal gas. The straw at present not utilised in Western Canada amounts to some 20,000,000 tons. From a ton of straw between 11,000 and 12,000 cubic feet of gas are obtainable. The heating value of straw gas is approximately 400 B.Th.U. per cubic foot. The gas from 20,000,000 tons of straw at 7,000 cubic feet per ton, in terms of power, would be equal to 2,511,000 h.p. years, or seven times the power generated at Niagara Falls on the Canadian side.

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—October 10, 1919.

No. 3491. OCTOBER 17, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Journal of the Royal Society of Arts.

No. 3,491. VOL. LXVII.

FRIDAY, OCTOBER 17, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COAL AND ITS CONSERVATION.

By WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S.,

Professor of Chemical Technology at the Imperial College of Science and Technology, London.

Lecture I.—Delivered March 10th, 1919.

COAL THE KEYSTONE OF THE ECONOMIC FABRIC.

INTRODUCTION.

From every point of view, whether geological, chemical, economic, social, or even, in these days, political, coal is a most important and fascinating study. In these Lectures I do not propose to deal, except incidentally, with its chemical or geological, but rather with certain economic aspects of the coal question which demand the attention of every intelligent citizen. I wish to call attention to certain arresting features of the new economic position created by the war which it would be at our peril as a nation to ignore. For, unless we resolve the coal situation in a manner consistent with the maintenance of our national economy and stability, there can be no doubt but that it will ultimately be our undoing as a commercial or industrial community.

Old King Coal is proving himself to be a hard taskmaster; of late he has become very truculent and defiant. He is out to show that he rules and that we, his subjects, must accommodate ourselves to his behests. He is now issuing his demands from the Robing Room of the House of Lords,* and threatens to overturn Governments, and to play havoc with the old social order, unless they are instantly obeyed. He complains of having to pay tribute to dukes, landowners, and merchants; of having his affairs managed by private individuals, whom he charges with all manner of incompetence and malpractice, and whom he would dismiss altogether from his service. He demands to be taken over, and generously provided for, by his subjects as a whole; and that his "aids" shall be deemed a first charge on their industry and enterprise. He is in a mood to brook no refusal; and our fearful politicians and Controllers hardly know how to answer him. The situation is indeed a grave and threatening one.

Coal is a commodity which is essential to the lief of a civilised community such as ours. Equally with the air we breathe, the food we eat, and the clothes we wear, it is a fundamental necessity of our daily life and occupation. As Jevons truly said, more than fifty years ago, it "in truth stands not beside, but entirely above, all other commodities. It is the material source of the energy of the country—the universal aid—the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times . . ." * The lapse of half a century has not in the least diminished the truth of this declaration, for despite the advent of petroleum, coal still retains its overwhelming supremacy as the world's fuel, and is likely to do so for many future generations. It may be confidently predicted that commercial and industrial prosperity will, as much in the future as in the past, go hand in hand with relatively cheap coal; and that those nations will prosper most who win their coal at the lowest cost and utilise it to the best advantage. Everything, therefore, depends upon the soundness of our "coal policy" as a whole, and upon our ability to take broad and long views. For whether it be in regard to research and investigation into the nature of coal and its best utilisation, or to the most economical methods of winning or distributing it, we shall undoubtedly stand or fall as an industrial

* The "Coal Industries Commission, 1919" had, at the date of the Lecture, begun its sittings under the presidency of Mr. Justice Sankey.

* W. Stanley Jevons on "The Coal Question." 1865.

nation according to the measure of our success in solving the never-ending series of problems that coal will present to us. Personally, I do not feel at all satisfied that we have yet really grasped the needs of the situation, or that the measures we are taking to meet it will prove adequate. I see very little appreciation of the problem of fundamental research into the nature of coal (not to speak of its utilisation), and I fear that those who have assumed the responsibility of directing our research policy have but little knowledge of, or disposition to provide for, its most essential requirements.

Great Britain's Former Supremacy in Coal and Shipbuilding.

When Jevons endeavoured, in 1865, to awaken public opinion to the vital importance of coal to the industrial future of the Kingdom, it held an unrivalled position as a producer of coal. For out of a total world's output of 130 million tons no less than 80 million tons, or 60 per cent., were raised in Great Britain. The then known immense coal reserves of North America, as well as those of the States until lately comprising the German Empire, had scarcely been touched. The proximity of all our principal coalfields either to the sea on the one hand, or to supplies of ironstone on the other, together with the natural skill and aptitude of our people in regard to mechanical invention, had combined to place us in a position of unique advantage over all other countries.

"The strength of Britain," as George Stephenson used to say, "lies in her iron and coal beds . . . The Lord Chancellor now sits upon a bag of wool; but wool has long since ceased to be emblematical of the staple commodity of England. He ought to sit upon a bag of coal."

If it be true to say that the world power of the British Empire is due to the supremacy of its mercantile marine, which ultimately depends upon the ability of this Kingdom to build ships more cheaply than any foreign rival, it may be with confidence asserted that the unchallengeable position which we had attained before the war was bound up with our abundant supplies of cheap coal and iron, combined with our favourable geographical position, climatic conditions, low nominal wages, and our policy of free imports.

Supremacy at sea is absolutely vital to the maintenance of what is sometimes called the British Empire; for, as a recent writer in the *Edinburgh Review* has truly observed, "Whenever the United States, or another nation, is our equal, still more when it is our superior on the sea, the British Empire will have lost its place in the world."

That supremacy we have held during the last fifty years because in no country in the wide world could ocean-going ships be built as cheaply as in this Kingdom. We shall inevitably lose it as soon as changing economic conditions make it possible to build them more cheaply elsewhere. And, as the aforesaid writer has remarked, the fact that at the conclusion of the war we are left "with a gravely diminished merchant shipping . . . is the shadow which dims the splendour of our victory."

The Effects of the War upon our Finances.

To any reflecting mind it must be clear that the catastrophe which overwhelmed Europe in August, 1914, has seriously undermined our economic position, and that the situation with which, after four and a half years of reckless inflation and prodigality, we are now faced is unexpectedly grave, threatening as it does our competence to recover from the wastage and demoralisation of war even a small measure of our former prosperity.

In order to finance the war, we have mortgaged our capital and future production so heavily that the War Debt now stands at almost half the estimated value of the accumulated wealth of the country in the year 1913, namely, at about £180 per head of population. It is doubtless true that, for the most part, "we owe it to ourselves"; but, all the same, the fact remains that the credit and material resources of the country have been *unproductively* expended at an appalling rate, and the inflation of its currency is an index of the consequent impoverishment of its producers. This inflation has now reached a point which is a menace to our foreign trade and world power.

It is imperative that no section of the community should remain under any delusion as to what the situation really is, and that all classes should be made to understand that the only possible way to retrieve it is to work more, spend less, and to get rid once and for all of the false and perilous notion that it is possible to pass out immediately from the hell of war into an earthly paradise. In the grave times that are now ahead of us every possible real economy will have to be exercised, and all unproductive public expenditure ruthlessly curtailed. Every scheme of "reconstruction" must be judged

by what it can be guaranteed to achieve in the way of real economy; reforms, however desirable, which are not likely to be *immediately* productive must be postponed—for we have no business to add to the public burdens by embarking upon doubtful enterprises merely because they will increase the "amenities" of life for the working-classes, or provide them more opportunities for whiling away more pleasantly their ever-increasing hours of leisure.

The Basic Fact of our Economic Position.

The central and basic fact of our economic position, and one which ought never to be forgotten, is that (unlike, for example, the United States) we are not naturally endowed with the capacity to produce in quantities sufficient for the needs of a modern industrial community a great variety of raw materials, nor can we grow sufficient food for our present working population. But our ships bring abundance of both food and raw materials from all parts of the world to our coal, and, without the impelling power of relatively cheap coal, we should neither be able to attract the raw materials, nor yet build or maintain the ships in which to convey them. Relatively cheap coal is the keystone of the whole economic structure. So long as we can produce relatively cheap coal, then, because of our geographical position, our trade connections, and our long experience in commerce, the raw materials will be attracted here. On the other hand, if we lose the attractive power of relatively cheap coal, the magnetism will begin to go, and ultimately we shall lose it altogether.

The cost of getting coal is largely a question of the cost of wages of the miners, and this again is largely a question of the cost of food. It is not unreasonable for any body of men who have to do hard physical work to ask to be recompensed for the increase in the cost of living. Therefore, any policy which aims at creating or maintaining high prices of food, in the supposed interests of the agricultural community, must inevitably mean high nominal wages and dear coal, both of which will assuredly diminish our importing power, and ultimately ruin our industrial system. Indeed, in this country we cannot at the same time have dear food and cheap coal; and without the latter our industrial system cannot long be maintained.

It, therefore, appears to me that the sooner we restore the pre-war policy of free importation of essential foodstuffs at "world prices" and abandon that of subsidising farmers under the "Corn-Production Act" the better for us. For the position that is rapidly developing as the result of the Coal Industries Commission will ere long involve a demand for a subsidy from the manufacturers of iron and steel, which, indeed, they are already receiving indirectly. This would inevitably lead to a policy of "subsidised industries" all round, which is a policy of decrepitude and despair. Indeed, a country such as ours, which, before the war, was approaching, if it had not already reached, the meridian of its industrial development, would not be able, on the basis of "subsidies" to its chief industries, to continue in economic health to a ripe and vigorous old age. Its development would be prematurely arrested, and senility would rapidly set in.

In order to illustrate and bring home to us these points, we need only turn to the official trade returns for the year 1913. In that year, the only raw materials which we produced in excess of our requirements were coal, clay, and salt. Of these, by far the most important was coal, of which we exported (in part to foreign countries, and in part to our coaling stations for ships' bunkers) 97·5 million tons, valued (f.o.b) at 52 million pounds sterling. Half of the 10·5 million tons of iron smelted in our furnaces was from imported ores, whilst (as the following figures show) we had to import the whole of the copper and cotton, 95 per cent. of the zinc, 90 per cent. of the lead, and about 80 per cent. of all the wood and timber used in British industrial establishments. In addition, we imported some 257 million pounds' worth of food, drink, and tobacco.

		Imported.	Produced at Home.
1. Copper	Metal	113,348	421 tons
	Regulus	39,110	
2. Lead		204,136	18,130 tons
3. Zinc		163,770	5,823 tons
4. Cotton		17,000,000 cwt.	nil
5. Wool (sheep's)		4,500,000	1,112,000 cwt.
6. Timber		338,669 tons	—

The total money values of foodstuffs and raw materials imported in the year 1913 were as follows:—

	Value of Net Imports. £ (mill.)
Food, drink, and tobacco	257·7
Raw materials and unmanufactured articles, including metals	230·7
Total	£488·4

The immense importing power which the foregoing figures disclose was due principally to three factors, namely:—

(*a*) Our exports of coal and manufactured products (export trade); (*b*) the earnings of our

mercantile marine (carrying trade); (c) interest on our foreign investments, bankers' and merchants' commissions, etc.

All this meant that we were freely exchanging with the outside world the products of British labour (either present or past) for the food and raw materials which were requisite for its maintenance, and that the factors which made such an immense exchange possible were *cheap coal* and *low nominal wages*,* both of which ultimately depend upon *cheap food*.

Undoubtedly the war has seriously impaired our importing power in that it has (*a*) for the time being, greatly reduced our export trade, the rapid and complete recovery of which is of vital importance to our future financial stability; (*b*) diminished the relative earnings of our ships, and quadrupled (or thereabouts) the cost of producing new tonnage; (*c*) caused us to sell a large proportion of our American securities, and to incur an outside debt of about £1,350 millions; and (*d*) about trebled the pit-head price of coal throughout the Kingdom.

No cheaper alternative to Coal for Great Britain as a source of Heat and Power.

The seriousness of the present situation is enhanced by the fact that as yet there is no cheaper alternative to *coal* in the Kingdom as a source of heat and power on any large scale.

It has recently been estimated that so far as Great Britain (*i.e.* excluding Ireland) is concerned, the total available *water-power* is not capable of generating more than about one million b.h.p. (or only about 8 per cent. of our present requirements), and of this only about 8 per cent. is actually being utilised. As regards Ireland, it has been stated that "the amount of power available is probably considerable, but without much closer investigations than have as yet been made even an approximate estimate cannot be given." (*Vide* "Preliminary Report of the Water Power Committee of the Conjoint Board of Scientific Societies, 1918," p. 12.)

Here again the Continent of North America, which (as will appear later) contains nearly 70 per cent. of the world's *total* coal reserves, is wonderfully endowed by Nature, thus:—

	Million Available.	B.h.p. Developed.	Per cent. Utilised.
U.S.A.	28·0	7·0	25
Canada	27·0	3·5	13
Total in North America	55·0	10·5	20

* Low *nominal* often means high *real* wages; a workman whose nominal wages have been *doubled* since 1914 is certainly no better, and perhaps even worse, off than he was, owing to the greater increase in the general prices of commodities.

There is, therefore, no likelihood of any possible development of water-power in the Kingdom supplying more than a small fraction of our industrial needs. Moreover, the technical difficulties connected with the large-scale production of a good commercial fuel of reasonable calorific intensity from raw peat (which contains water = 90, peat = 10) are as yet so far from solution that its utilisation cannot at present be regarded as having more than local importance, although in Ireland it may, at some future time, attain to greater significance.

Again, notwithstanding the sanguine forecasts of journalistic experts, there is nothing in recent "oil-boring" operations or discoveries to suggest that native petroleum will be found in quantities sufficient for it to replace coal in the national economy. We are thus driven back again to coal as our great national power-asset, and accordingly our policy should be directed with a view to winning it at the lowest possible cost consistent with the safety of the mines and a decent standard of living for the workers therein, and to utilising it with the best possible advantage.

The World's Coal Reserves and Requirements.

Before passing to the important question of the present cost of producing coal in Great Britain, it may be well for us to consider for a moment how we stand, both as a nation and an empire, in regard to "coal reserves" as compared with other parts of the world.

According to a report upon the world's coal resources issued by the International Geological Congress in the year 1913, the total probable and possible reserves of all kinds of coal (*i.e.* anthracite, bituminous coals, and lignite) within 6,000 feet of the earth's surface, are estimated to amount to

7,397,553 million metric tons.

Of such huge reserves, which are approximately 6,000 times the world's present total annual consumption, 6·75 are anthracite (mainly located in China), 52·75 are bituminous coals, and 40·5 per cent. belong to the much less valuable sub-bituminous class, which includes all the brown coals and lignites.

With regard to their geographical distribution, no less than 69 per cent. of the total reserves are located in America (and nearly all in North America), 17·3 per cent. in Asia, 10·6 per cent. in Europe, 2·4 per cent. in Oceania, and only 0·8 per cent. in Africa. Or, looking at the matter from the standpoint of the various

nations, 51·8 per cent. of the estimated reserves are located in the United States, 16·4 per cent. in Canada, 13·5 per cent. in China, 5·7 in the territory which, until recently, comprised Germany, 2·6 per cent. in Great Britain, 2·3 per cent. in Siberia, 2·2 per cent. in Australia, and only 0·8 per cent. in Russia.

Hence it will be seen that the available coal reserves of Great Britain amount to one-fortieth only, and those of the whole Empire to not more than one-fourth, of the world's estimated total. Comparing Great Britain's position with that of the United States, our future greatest competitor in the world's markets, it may be said that, after making due allowance for the fact that, whereas our reserves consist wholly of high grade anthracitic and bituminous classes, half those of the States comprise inferior brown coals and lignites, it still remains that, *per head of present population*, the States possesses somewhere between six and eight times as much coal fuel as we do. We, however, possess two important natural advantages, namely, our geographical position and the proximity of our best coalfields to our ports.

Throughout the half-century period 1864–1913 inclusive, the world's demands for coal had been steadily increasing at an average rate of 5 per cent. "compound interest" per annum, until in 1913 they had reached the huge total of 1 250 million tons.

During the last decade of the period these demands had been principally supplied by three countries, namely, the United States, Great Britain, and Germany, whose respective coal productions since the beginning of the century may be summarised in the following quinquennial averages:—

Period.	United States.	Great Britain.	Germany.
	Million tons per annum.		
1900-4	288·2	226·8	112·5
1905-9	400·5	256·0	139·8
1910-14	519·2	269·9	168·7
Approximate percentage compound interest increase	6·0	2·0	4·0

Having regard, however, to our more limited resources, there was nothing to be alarmed at about the greater percentage increases in the outputs of both the United States and Germany as compared with our own. As a matter of fact before the war our coal trade was in a very prosperous condition. We could produce coal for our home market quite as cheaply as Germany could for hers, and, so far as foreign markets were concerned, we had so dominated the position that, in 1913, we actually transacted over 70 per cent. of the whole sea-borne coal trade of the world, much to our advantage as a world Power dependent upon the supremacy of its mercantile marine. Indeed, what export trade our two competitors were able to transact was, in both cases, chiefly landwards. We exported coal on the average at higher prices than those at which we supplied ourselves, and as most of it was carried out in our own ships, we were able in this way to earn a considerable proportion of the value of the food and raw materials which they brought back.

I have met with, and read the writings of, many distinguished people who, on "patriotic" grounds, used to deplore the huge coal output trade which we carried on so successfully in pre-war days. Holding, as I do, the view that a large export trade in coal is a basic necessity of the maintenance of the supremacy of our mercantile marine, now so threatened, and also that it is a large factor in the importing power upon which the future maintenance of our industries depends, I could never attach much weight to their fulminations against it. It will certainly now not be wise for us to impose any export restrictions upon the coal trade, because the more coal we can export for some time after the war the sooner shall we pay off our foreign war debt and re-establish the pre-war condition of the exchanges.

Comparison of Coal Output and Prices in Great Britain and the United States since 1913.

A most disquieting, not to say alarming, feature about our coal industry, as compared with that of the United States, and of which our politicians, Coal Controllers, and Miners' Federations, seem to be singularly oblivious, is our now steadily declining outputs and steadily increasing costs of production, which are in striking contrast to the conditions prevailing in America. How serious the situation here has become will be seen from the following statistics, which speak for themselves, and require no enlarging upon.

Outputs of Coal and Average Pithead Prices in Great Britain.

Year.	Total Output (Million Tons).	Annual Output per Person Employed.	Average Pithead Price per Ton.
		Tons.	s. d.
1913	287·4	260	10 1
1914	265·6	238	10 0
1915	253·2	270	12 6
1916	256·3	260	15 7
1917	248·0	247	16 9
1918	227·7	232	(25 0)

It would be interesting to hear what explanation Mr. Robert Smillie has to offer of the remarkable decline in the "annual output per person employed" in British mines, which unfortunately has been a peculiar feature of our industry for many years back, as the following figures indicate:—

Period.	Average output per person employed in British mines. Tons.
1883–92	320
1893–02	295
1903–12	280
1913–18	251

Professor Henry Louis, in commenting upon such figures as these in an address delivered to the London Section of the Society of Chemical Industry on December 4th, 1917, expressed the opinion that the decline in the annual output per man employed in British mines "may be to some little extent accounted for by the fact that the thicker and more easily worked seams are gradually becoming exhausted, and the production from the thinner seams is gradually forming an increasing proportion of the total, but the diminution in efficiency due to this cause should be far more than counterbalanced by the increased use of underground machinery, especially of coal cutters and face conveyors, which greatly multiply the working capacity of the hewer.*

Comparing such outputs with those obtained in German and American mines during the three triennial periods immediately preceding the war, we obtain the following suggestive series of figures:—

COMPARATIVE ANNUAL OUTPUTS IN TONS PER WORKER EMPLOYED IN THE MINES IN

Triennial Period.	Great Britain.	Germany.	United States.
1905–7	289	248	589
1908–10	265	239	591
1911–13	254	263	651

It would thus appear that whereas in German mines, the general conditions in which may fairly be compared with those in ours, the output per person employed had distinctly improved between 1905 and 1913, ours had fallen off by something like 12 per cent. The comparison suggests that, for some reason or other, there has been something operative in the British industry very much like restriction of output.

It is, perhaps, hardly fair to draw any definite conclusion as to relative efficiencies per worker from a comparison between the British and American figures, because, owing to shallower depths, much thicker seams, and the greater employment of machinery, coal is much more easily won in American mines than in ours. Nevertheless such an admission does not alter the ominous economic significance of the following remarkable figures:—

OUTPUTS OF COAL IN THE UNITED STATES DURING THE PERIOD 1913–17.

Year.	Total Output.	Output per Worker employed at the Mines.
	Million tons.	Tons.
1913	508·9	681
1914	458·5	601
1915	474·6	647
1916	526·9	732
1917	581·7	768

It would thus appear that in the year 1917 the American output per worker employed was more than three times that realised in British mines, a fact which (whatever its explanation) is of most serious import.

War conditions have sent up the prices of coal to consumers both in this country and in America, although at a greater rate here than there. Also it is of significance that, whereas American wholesale coal and coke prices rose sharply during the latter half of 1916, and reached a maximum about the middle of 1917, when they suddenly dropped "under control," the effect of the activities of our Coal Control Department has rather been to accentuate and apparently perpetuate the "war rise," a warning against State control of industry. How much more the poor British consumer has suffered, in comparison with his American cousin, will be apparent from a study of the tables given on page 743:—

CONCLUDING REMARKS (September, 1919).

One of the most serious results of the war has been to treble the cost of producing coal at the pithead in Great Britain, and including the recent rise of six shillings per ton, imposed as the result of the Sankey Commission, upon the price to all consumers, whether domestic or industrial, we have handicapped our manufacturers, as compared with those of America, with a greater burden than can be borne if we are to compete successfully with our rivals in the world's market. We have also curtailed our coal export trade at a time when its revival would be of the greatest benefit to us. Some of the blame for this unsatisfactory state of things must, I fear, be laid at the door

* *Journal of the Society of Chemical Industry*, (1918) 36.

PRICE PER TON PAID BY CONSUMERS IN GREAT BRITAIN.

Year.	In London for Best House Coal delivered.	For Gas Coal by the South Metropolitan Gas Co.		For Durham Coking Coal at a Cleveland Ironworks.*
		f.o.b. at N.E. Coast.	Cost into Works.	
	s. d.	s. d.	s. d.	s. d.
1914	29 0	11 2	14 6	13 0
1915	34 3	15 5	22 11	16 2
1916	37 0	16 5	26 4	22 3
1917	38 0	16 8	32 5	22 10
1918	44 0	20 11	34 4	24 5

* The corresponding pithead prices would be about 3*s.* 6½*d.* less than these. The average price (at the works) during the first six months of 1919 has been 26*s.* 6*d.* per ton.

AVERAGE WHOLESALE PRICES OF COAL AND COKE PER LONG TON IN THE UNITED STATES FOR EACH YEAR SINCE 1913.

Year.	Stove Anthracite at New York.	Semi-bituminous Pocahontas, f.o.b. Norfolk, Va.	Bituminous Pittsburg, Run of Mine, f.o.b. Cincinnati.	Connelsville Coke.
	s. d.	s. d.	s. d.	s. d.
1914	21 1	12 6	10 3	8 5
1915	21 0	11 10	10 3	8 4
1916	22 9	15 6	12 6	15 2
1917	23 5	22 8	21 5	38 6
1918	27 1	18 8	18 1	28 0

of Government control and interference, and the sooner the coal trade is allowed to manage its own affairs again the better for the nation as a whole. The whole coal distribution trade needs overhauling, and every effort should be made to reduce the prices of food and other essential commodities so that the costs of producing coal at British mines can be lowered to a more tolerable level. National prosperity cannot be restored until coal prices have been substantially reduced. We are living in an age when world-power depends upon the relatively cheap production of coal and iron. A nation that deliberately throws away or diminishes its advantages in this respect is, economically speaking, digging its own grave.

THE DIFFERENTIATION OF MANKIND INTO RACIAL TYPES.*

For a brief half-hour I am to try and engage your attention on a matter which has excited the interest of thoughtful minds from ancient times—the problem of how mankind has been demarcated into types so diverse as the Negro, the Mongol, and the Caucasian or European. For many a day the Mosaic explanation—the tower of Babel theory—was regarded as a sufficient explanation of this difficult problem. In these times most of us have adopted an explanation which differs in many respects from that put forward in the book of Genesis; Noah disappears from our theory and is replaced in the dim distance of time by a "common ancestral stock." Our story now commences, not at the close of a historical flood, but at the end of a geological epoch so distant from us that we cannot compute its date with any degree of accuracy. Shem, Ham, and Japheth, the reputed ancestors of the three great racial stocks of modern times—the white, black, and yellow distinctive types of mankind—have also disappeared from our speculations; we no longer look out on the world and believe that the patterns which stud the variegated carpet of humanity were all woven at the same time; some of the patterns, we believe, are of ancient date and have retained many of the features which marked the "common ancestral" design; others are of more recent date, having the ancient pattern altered in many of its details. We have called in, as Darwin has taught us, the whole machinery of evolution—struggle for existence, survival of the fittest, spontaneous origin of structural variations, the inheritance of such variations—as the loom by which Nature fashions her biological patterns. We have replaced the creative finger by the evolutionary machine, but no one is more conscious of the limitations of that machine than the student of human races. We are all familiar with the features of that racial human type which clusters round the heart of Africa; we recognise the Negro at a glance by his black, shining, hairless skin, his crisp hair, his flattened nose, his widely opened dark eyes, his heavily moulded lips, his gleaming teeth and strong jaws. He has a carriage and proportion of body of his own; he has his peculiar quality of voice and action of brain. He is, even to the

* Address to the Anthropological Section of the British Association by Professor Arthur Keith, M.D., LL.D., F.R.S., President of the Section.

unpractised eye, clearly different from the Mongolian native of North-Eastern Asia; the skin, the hair, the eyes, the quality of brain and voice, the carriage of body and proportion of limb to body pick out the Mongol as a sharply differentiated human type. Different from either of these is the native of Central Europe—the Aryan or Caucasian type of man; we know him by the paleness of his skin and by his facial features—particularly his narrow, prominent nose and thin lips. We are so accustomed to the prominence of the Caucasian nose that only a Mongol or Negro can appreciate its singularity in our aryanised world. When we ask how these three types—the European, Chinaman, and Negro—came by their distinctive features, we find that our evolutionary machine is defective; the processes of natural and of sexual selection will preserve and exaggerate traits of body and of mind, but they cannot produce that complex of features which marks off one racial type from another. Nature has at her command some secret mechanism by which she works out her new patterns in the bodies of man and beast—a mechanism of which we were almost ignorant in Darwin's day, but which we are now beginning to perceive and dimly understand. It is the bearing of this creative or morphogenetic mechanism on the evolution of the modern races of mankind that I propose to make the subject of my address.

Hidden away in various parts of the human frame is a series of more or less obscure bodies or glands, five in number, which, in recent times, we have come to recognise as parts of the machinery which regulate the growth of the body. They form merely a fraction of the body—not more than $\frac{1}{180}$th part of it; a man might pack the entire series in his watch-pocket. The modern medical student is familiar with each one of them—the pituitary body, about the size of a ripe cherry, attached to the base of the brain and cradled in the floor of the skull; the pineal gland, also situated in the brain, and in point of size but little larger than a wheat-grain; the thyroid in the neck, set astride the windpipe, forms a more bulky mass; the two suprarenal bodies situated in the belly, capping the kidneys, and the interstitial glands embedded within the substance of the testicle and ovary, complete the list. The modern physician is also familiar with the fact that the growth of the body may be retarded, accelerated, or completely altered if one or more of these glands becomes the seat of injury or of a functional disorder. It is thirty-three years now since first one woman and then another came to Dr. Pierre Marie in Paris seeking relief from a persistent headache, and mentioning incidentally that their faces, bodies, hands, and feet had altered so much in recent years that their best-known friends failed to recognise them. That incident marked the commencement of our knowledge of the pituitary gland as an intrinsic part of the machinery which regulates the shaping of our bodies and features. Dr. Marie named the condition acromegaly. Since then hundreds of men and women showing symptoms similar to those of Dr. Marie's patients have been seen and diagnosed, and in every instance where the acromegalic changes were typical and marked there has been found a definite enlargement or tumour of the pituitary body. The practised eye recognises the full-blown condition of acromegaly at a glance, so characteristic are the features of the sufferers. Nay, as we walk along the streets we can note slight degrees of it—degrees which fall far short of the border-line of disease; we note that it may give characteristic traits to a whole family—a family marked by what may be named an acromegalic taint. The pituitary gland is also concerned in another disturbance of growth—giantism. In every case where a young lad has shot up, during his late "teens," into a lanky man of seven feet or more—has become a giant—it has been found that his pituitary gland was the site of a disordered enlargement. The pituitary is part of the mechanism which regulates our stature, and stature is a racial characteristic. The giant is usually acromegalic as well as tall, but the two conditions need not be combined; a young lad may undergo the bodily changes which characterise acromegaly and yet not become abnormally tall, or he may become—although this is rarely the case—a giant in stature and yet may not assume acromegalic features. There is a third condition of disordered growth in which the pituitary is concerned—one in which the length of the limbs is disproportionately increased—in which the sexual system and all the secondary sexual characters of body and mind either fail to develop or disappear—where fat tends to be deposited on the body, particularly over the buttocks and thighs—where, in brief, a eunuchoid condition of body develops. In all of these three conditions we seem to be dealing with a disordered and exaggerated action of the pituitary gland; there must be conditions of an opposite kind where the functions of the pituitary are disordered and reduced. A number of cases of dwarfism have been recorded where boys or girls retained their boyhood or girlhood throughout life, apparently because their pituitary gland had been invaded and partly destroyed by tumours. We shall see that dwarfism may result also from a failure of the thyroid gland. On the evidence at our disposal, evidence which is being rapidly augmented, we are justified in regarding the pituitary gland as one of the principal pinions in the machinery which regulates the growth of the human body and is directly concerned in determining stature, cast of features, texture of skin, and character of hair—all of them marks of race. When we compare the three chief racial types of humanity—the Negro, the Mongol, and the Caucasian or European—we can recognise in the last-named a greater predominance of the pituitary than in the other two. The sharp and pronounced nasalisation of the face, the tendency to strong eyebrow ridges, the prominent chin, the tendency to bulk of body and height of

stature in the majority of Europeans, is best explained, so far as the present state of our knowledge goes, in terms of pituitary function.

There is no question that our interest in the mechanism of growth has been quickened in recent years by observations and discoveries made by physicians on men and women who suffered from pituitary disorders, but that a small part of the body could influence and regulate the growth and characterisation of the whole was known in ancient times. For many centuries it has been common knowledge that the removal of the genital glands alters the external form and internal nature of man and beast. The sooner the operation is performed after birth the more certain are its effects. Were a naturalist from a unisexual world to visit this earth of ours it would be difficult to convince him that a brother and a sister were of the same species, or that the wrinkled, sallow-visaged eunuch with his beardless face, his long, tapering limbs, his hesitating carriage, his carping outlook and corpulent body, was brother to the thick-set, robust, pugilistic man with the bearded face. The discovery that the testicle and ovary contain, scattered throughout their substance, a small glandular element which has nothing to do with their main function — the production of genital cells — was made seventy years ago, but the evidence which leads us to believe that this scattered element—the interstitial gland—is directly concerned in the mechanism of growth is of quite recent date. All those changes which we may observe in the girl or boy at puberty—the phase of growth which brings into full prominence their racial characteristics—depend on the action of the interstitial glands. If they are removed or remain in abeyance, the maturation of the body is both prolonged and altered. In seeking for the mechanism which shapes mankind into races, we must take the interstitial gland into our reckoning. I am of opinion that the sexual differentiation — the robust manifestations of the male characters — is more emphatic in the Caucasian than in either the Mongol or Negro racial types. In both Mongol and Negro, in their most representative form, we find a beardless face and almost hairless body, and in certain Negro types, especially in Nilotic tribes, with their long, stork-like legs, we seem to have a manifestation of abeyance in the action of the interstitial glands. At the close of sexual life we often see the features of a woman assume a coarser and more masculine appearance.

Associated with the interstitial glands, at least in point of development, are the suprarenal bodies or glands. Our knowledge that these two comparatively small structures, no larger than the segments into which a moderately sized orange can be separated, are connected with pigmentation of the skin dates back to 1894, when Dr. Thomas Addison, a physician to Guy's Hospital, London, observed that gradual destruction of these bodies by disease led to a darkening or pigmentation of the patient's skin, besides giving rise to other more severe changes and symptoms. Now it is 150 years since John Hunter came to the conclusion, on the evidence then at his disposal, that the original colour of man's skin was black, and all the knowledge that we have gathered since his time supports the inference he drew. From the fact that pigment begins to collect in and thus darken the skin when the suprarenal bodies become the seat of a destructive disease, we infer that they have to do with the clearing away of pigment, and that we Europeans owe the fairness of our skins to some particular virtue resident in the suprarenal bodies. That their function is complex and multiple, the researches of Sharpey Schafer, of T. R. Elliott, and of W. B. Cannon have made very evident. Fifteen years ago Bulloch and Sequeira established the fact that when a suprarenal body becomes the site of a peculiar form of malignant overgrowth in childhood, the body of the boy or girl undergoes certain extraordinary growth changes. The sexual organs become rapidly mature, and through the framework of childhood burst all the features of sexual maturity—the full chest, muscularity of limbs, bass voice, bearded face, and hairy body—a miniature Hercules — a miracle of transformation in body and brain. Corresponding changes occur in young girls—almost infants in years — with a tendency to assume features which characterise the male. Professor Glynn* has recently collected such cases, and systematised our knowledge of these strange derangements of growth. There can be no doubt that the suprarenal bodies constitute an important part of the mechanism which regulates the development and growth of the human body and help in determining the racial characters of mankind. We know that certain races come more quickly to sexual maturity than others, and that races vary in development of hair and of pigment, and it is therefore reasonable to expect a satisfactory explanation of these characters when we have come by a more complete knowledge of the suprarenal mechanism.

During the last few years the totally unexpected discovery has been sprung upon us that disease of the minute pineal gland of the brain may give rise to a train of symptoms very similar to those which follow tumour formation of the cortex of the suprarenal bodies. In some instances the sudden sexual prematurity which occurs in childhood is apparently the immediate result of a tumour-like affection of the pineal gland. We have hitherto regarded the pineal gland, little bigger than a wheat-grain and buried deeply in the brain, as a mere useless vestige of a median or parietal eye, derived from some distant human ancestor in whom that eye was functional, but on the clinical and experimental evidence now rapidly accumulating, we must assign to it a place in the machinery which controls the growth of the body.

We come now to deal with the thyroid gland, which, from an anthropological point of view, must be regarded as the most important of all the organs

* *Quarterly Journal of Medicine*, 1912, vol. v. p. 157.

or glands of internal secretion. Here, too, in connection with the thyroid gland—which is situated in the front of the neck, where it is so apt to become enlarged and prominent in women—I must call attention to a generalisation which I slurred over, when speaking of the pituitary and suprarenal glands. Each of these glands throws into the circulating blood two sets of substances—one set to act immediately in tuning the parts of the body which are not under the influence of the will, to the work they have to do when the body is at rest and when it is making an effort; another set of substances — which Professor Gley has named morphogenetic — has not an immediate but a remote effect; they regulate the development and co-ordinate the growth of the various parts of the body. Now, so far as the immediate function of the thyroid is concerned, our present knowledge points to the gland as the manufactory of a substance which, when circulating in the body, regulates the rate of combustion of the tissues; when we make a muscular effort, or when our bodies are exposed to cold, or when we become the subjects of infection, the thyroid is called upon to assist in mobilising all available tissue-fuel. If we consider only its immediate function it is clear that the thyroid is connected with the selection and survival of human races. When, however, we consider its remote or morphogenetic effects on growth its importance as a factor in shaping the characteristics of human races becomes even more evident. In districts where the thyroid is liable to that form of disease known as goitre it has been known for many a year that children who were affected become cretins—dwarf idiots with a very characteristic appearance of face and body.* Disease of the thyroid stunts and alters the growth of the body so that the subjects of this disorder might well be classed as a separate species of humanity. If the thyroid becomes diseased and defective after growth of the body is completed then certain changes, first observed by Sir William Gull in 1873, are set up and give rise to the disordered state of the body known as myxœdema. "In this state," says Sir Malcolm Morris,† "the skin is cold, dry and rough, seldom or never perspires, and may take on a *yellowish* tint; there is a bright red flush in the malar region. The skin as a whole looks transparent; the hair of the scalp becomes scanty; the pubic and axillary hair, with the eyelashes and eyebrows, often falls out; in many cases the teeth are brittle and carious. All these appearances disappear under the administration of thyroid extract." We have here conclusive evidence that the thyroid acts directly on the skin and hair, just the structures we employ in the classification of human races. The influence of the thyroid on the development of the other systems of the body, particularly on the growth of the skull and skeleton, is equally profound. This is particularly the case as regards the base of the skull and the nose. The arrest of growth falls mainly on the basal part of the skull, with the result that the root of the nose appears to be flattened and drawn backwards between the eyes, the upper forehead appears projecting or bulging, the face appears flattened, and the bony scaffolding of the nose, particularly when compared to the prominence of the jaws, is greatly reduced. Now these facial features which I have enumerated give the Mongolian face its characteristic aspect, and, to a lesser degree, they are also to be traced in the features of the Negro. Indeed, in one aberrant branch of the Negro race—the Bushman of South Africa—the thyroid facies is even more emphatically brought out than in the most typical Mongol. You will observe that, in my opinion, the thyroid—or a reduction or alteration in the activity of the thyroid—has been a factor in determining some of the racial characteristics of the Mongol and the Negro races. I know of a telling piece of evidence which supports this thesis. Some years ago there died in the East End of London a Chinese giant —the subject, we must suppose, of an excessive action of the pituitary gland—the gland which I regard as playing a predominant part in shaping the face and bodily form of the European. The skeleton of this giant was prepared and placed in the Museum of the London Hospital Medical College by Colonel T. H. Openshaw, and anyone inspecting that skeleton can see that, although certain Chinese features are still recognisable, the nasal region and the supra-orbital ridges of the face have assumed the more prominent European type.

There are two peculiar and very definite forms of dwarfism with which most people are familiar, both of which must be regarded as due to a defect in the growth-regulating mechanism of the thyroid. Now, one of these forms of dwarfism is known to medical men as Achondroplasia, because the growth of cartilage is particularly affected, but in familiar language we may speak of the sufferers from this disorder of growth as being of the "bulldog breed" or of the "dachshund breed." In the dachshund the limbs are greatly shortened and gnarled, but the nose or snout suffers no reduction, while in the bulldog the nose and nasal part of the face are greatly reduced and withdrawn, showing an exaggerated degree of Mongolism. Among achondroplastic human dwarfs both breeds occur, but the "bulldog" form is much more common than the "dachshund" type. The shortening of limbs with retraction of the nasal region of the face—pug-face or prosopia we may call the condition —has a very direct interest for anthropologists, seeing that short limbs and a long trunk are well-recognised racial characteristics of the Mongol. In the second kind of dwarfism, which we have reason to regard as due to a functional defect of the thyroid, the Mongolian traits are so apparent that the sufferers from this disorder are known to

* The story of the discovery of the action of the thyroid gland is told by Professor G. M. Murray, *British Medical Journal*, 1913, ii. p. 163.

† *British Medical Journal*, 1913, i. p. 1038.

medical men as "Mongolian idiots"—for not only is their growth stunted, but their brains also act in a peculiar and aberrant manner. Dr. Langdon Down, who gave the subjects of this peculiar disorder the name "Mongolian idiots" fifty-five years ago, knew nothing of the modern doctrine of internal secretions, but that doctrine has been applied in recent years by Dr. F. G. Crookshank* to explain the features and condition of Mongoloid imbecile children. Some years ago † I brought forward evidence to show that we could best explain the various forms of anthropoid apes by applying the modern doctrine of a growth-controlling glandular mechanism. In the gorilla we see the effects of a predominance of the pituitary elements; in the orang, of the thyroid. The late Professor Klaatsch tried to account for the superficial resemblances between the Malay and the orang by postulating a genetic relationship between them; for a similar reason he derived the Negro type from a gorilline ancestry. Occasionally we see a man or woman of supposedly pure European ancestry displaying definite Mongoloid traits in their features. We have been in the habit of accounting for such manifestations by the theory, at one time very popular, that a Mongoloid race had at one time spread over Europe, and that Mongoloid traits were atavistic recurrences. An examination of the human remains of ancient Europe yields no evidence in support of a Turanian or Mongol invasion of Europe.

All of these manifestations to which I have been calling your attention—the sporadic manifestation of Mongoloid characters in diseased children and in healthy adult Europeans, the generic characters which separate one kind of ape from another, the bodily and mental features which mark the various races of mankind—are best explained by the theory I am supporting, namely, that the conformation of man and ape and of every vertebrate animal is determined by a common growth-controlling mechanism which is resident in a system of small but complex glandular organs. We must now look somewhat more closely into the manner in which this growth-regulating mechanism actually works. That we can do best by taking a glimpse of a research carried out by Bayliss and Starling in the opening years of the present century. They were seeking to explain why it was that the pancreas poured out its digestive juice as soon as the contents of the stomach commenced to pass into the first part of the duodenum. It was then known that if acid was applied to the lining epithelial membrane of the duodenum, the pancreas commenced to work; it was known also that the message which set the pancreas into operation was not conveyed from the duodenum to the pancreas by nerves, for when they were cut the mechanism was still effective. Bayliss and Starling solved the puzzle by making an emulsion from the acid-soaked lining epithelium of the duodenum and injecting the extract of that emulsion into the circulating blood. The result was that the pancreas was immediately thrown into activity. The particular substance which was thus set circulating in the blood and acted on the pancreas and on the pancreas alone, and which thus served as a messenger or hormone, they named secretin. They not only cleared up the mechanism of pancreatic secretion, but at the same time made a discovery of much greater importance. They had discovered a new method whereby one part of the human body could communicate with and control another. Up to that time we had been like an outlandish visitor to a strange city, who believed that the visible telegraph or telephone wires were the only means of communication between its inhabitants. We believed that it was only by nerve fibres that intercommunication was established in the animal body. Bayliss and Starling showed that there was a postal system. Missives posted in the general circulation were duly delivered at their destinations. The manner in which they reached the right address is of particular importance for us; we must suppose that the missive or hormone circulating in the blood and the recipient for which they are intended have a special attraction or affinity for each other—one due to their physical constitution —and hence they and only they come together as the blood circulates round the body. Secretin is a hormone which effects its errand rapidly and immediately, whereas the growth or morphogenetic hormones, thrown into the circulation by the pituitary, pineal, thyroid, suprarenals, and genital glands, act slowly and remotely. But both are alike in this: the result depends not only on the nature of the hormone or missive, but also on the state of the local recipient. The local recipient may be specially greedy, as it were, and seize more than a fair share of the manna in circulation, or it may have "sticky fingers" and seize what is not really intended for local consumption. We can see that local growth—the development of a particular trait or feature—is dependent not only on the hormones supplied to that part, but also on the condition of the receptive mechanism of the part. Hence we can understand a local derangement of growth—an acromegaly or giantism confined to a finger or to the eyebrow ridges, to the nose, to one side of the face, and such local manifestations are not uncommon. It is by a variation in the sensitiveness of the local recipient that we have an explanation of the endless variety to be found in the relative development of racial and individual features.

Some ten years after Starling had formulated the theory of hormones, Professor W. B. Cannon, of Harvard University, piecing together the results of researches by Dr. T. R. Elliott and by himself, on the action of the suprarenal glands, brought to light a very wonderful hormone mechanism—one which helps us in interpreting the action of growth-regulating hormones. When we are about to make a severe bodily effort it is necessary to flood our muscles with blood, so that they may have at

* The *Universal Medical Record*, 1913, vol. iii. p. 12.

† *Journal of Anatomy and Physiology*, 1913.

their disposal the materials necessary for work —oxygen and blood-sugar, the fuel of muscular engines. At the beginning of a muscular effort the suprarenal glands are set going by messages passing to them from the central nervous system; they throw a hormone—adrenalin—into the circulating blood, which has a double effect; adrenalin acts on the floodgates of the circulation, so that the major supply of blood passes to the muscles. At the same time it so acts on the liver that the blood circulating through that great organ becomes laden with blood-sugar. We here obtain a glimpse of the neat and effective manner in which hormones are utilised in the economy of the living body. From that glimpse we seem to obtain a clue to that remarkable disorder of growth in the human body known as acromegaly. It is a pathological manifestation of an adaptational mechanism with which we are all familiar. Nothing is better known to us than that our bodies respond to the burden they are made to bear. Our muscles increase in size and strength the more we use them; increase in the size of our muscles would be useless unless our bones also were strengthened to a corresponding degree. A greater blood supply is required to feed them, and hence the power of the heart has to be augmented; more oxygen is needed for their consumption, and hence the lung capacity has to be increased; more fuel is required—hence the whole digestive and assimilative systems have to undergo a hypertrophy, including the apparatus of mastication. Such a power of co-ordinated response on the part of all the organs of the body to meet the needs of athletic training, presupposes a co-ordinating mechanism. We have always regarded such a power of response as an inherent property of the living body, but in the light of our growing knowledge it is clear that we are here dealing with a hormonic mechanism, one in which the pituitary gland is primarily concerned. When we study the structural changes which take place in the first phase of acromegaly,* we find that not only are the bones enlarged and overgrown in a peculiar way, but so are the muscles, the heart, the lungs, the organs of digestion, particularly the jaws; hence the marked changes in the face, for the form of the face is determined by the development of the upper and lower jaws. The rational interpretation of acromegaly is that it is a pathological disorder of the mechanism of adaptational response; in the healthy body the pituitary is throwing into the circulation just a sufficiency of a growth-regulating substance to sensitise muscles, bones, and other structures to give a normal response to the burden thrown on the body. But in acromegaly the body is so flooded with this substance that its tissues become hypersensitive and respond by overgrowth to efforts and movements of the slightest degree. It is not too much to expect, when we see how the body and features become transformed at the onset of acromegaly, that a fuller knowledge of these growth mechanisms will give us a clue to the principles of race differentiation.

* See Keith, *Lancet*, 1911, ii. p. 993; 1913, i. p. 305.

There must be many other mechanisms regulated by hormones with which we are as yet totally unacquainted. I will cite only one instance—that concerned in regulating the temperature of the body. We know that the thyroid and also the suprarenal glands are concerned in this mechanism; they have also to do with the deposition and absorption of pigment in the skin, which must be part of the heat-regulating mechanism. It is along such a path of inquiry that we expect to discover a clue to the question of race colour.

This is not the first occasion in which the doctrine of hormones has been applied to biological problems at the British Association. In his Presidential address to the Zoological Section at Sheffield in 1910, Professor G. C. Bourne applied the theory to the problems of evolution: its bearing was examined in more detail in an address to the same section by Professor Arthur Dendy during the meeting at Portsmouth in 1911. At the meeting of the Association at Newcastle in 1916 Professor MacBride devoted part of his address to the morphogenetic bearings of hormones. Very soon after Starling formulated the hormone theory, Dr. J. T. Cunningham applied it to explain the phenomena of heredity.* Nay, rightly conceived. Darwin's theory of Pan-genesis is very much of the same character as the modern theory of hormones.

THE RAILWAY STRIKE AND MILK SUPPLY.

The following letter from the *Times* of October 11th is of interest in connection with Professor Armstrong's recently published lectures on "Food Problems," and his appeal for an improved quality of milk:—

TO THE EDITOR OF THE TIMES.

Sir,—The incidents of the railway strike are still fresh, and we have not forgotten the efficient manner in which the Government utilised road transport for the conveyance of milk and perishable foodstuffs to the metropolis and other centres of industry. Much has been made of the harm which has been done, but few would anticipate that, despite the chaos of that memorable week, our infant population was actually better off.

I have been surprised to find among my infant out-patients at a children's hospital in the South-East of London that all the children suffering from wasting diseases, the diarrhœa of infancy, and similar nutritional complaints, have increased in weight to a greater extent than was usual before the strike, and are, as testified by their happy mothers, well on the road to recovery. The change can be attributed, in my opinion, to nothing save the fact that they have been fed on fresher and purer milk. I have the same evidence from an infant welfare centre in the East End of London, where the children are for the

* Dr. J. T. Cunningham, *Proceedings of the Zoological Society, London*, 1908, p. 434.

most part healthy; and also from the mothers of many families of better social status.

Of one factor I am certain: that London milk during the strike was fresher than the milk normally purveyed. I do not suggest that milk as sold is always "graded down" to a standard cream content, but I would urge most strongly that when the time comes for the establishment of milk dispensaries in connection with child welfare in industrial centres, milk may be conveyed expeditiously and directly from farm to dispensary, and, be it noted, in locked and sealed churns, much in the same manner that our mails are carried to-day.

I am, Sir, your obedient servant,

A CHILD-LOVER.

CINCHONA CULTIVATION IN BENGAL.

Cinchona, the source of quinine, which is so widely used in the treatment of malarial fevers, has been cultivated in India for the last six decades, but on account of the increased demand caused by the war the industry has received greater attention during the past four years. The Government operates two cinchona plantations and a factory in the Province of Bengal, the annual report of which shows that during the three years 1915–1918 over 192,000 lb. of quinine were issued. This quantity exceeds the total issues for the twenty-two years from 1887 (when quinine was first made in the factory) to 1908. A great part of the extra demand has been for the armies.

In the past considerable quantities of cinchona bark have been imported from Java, but it is expected that in two or three years the two Government plantations at Mungpoo and Munsong will yield sufficient bark to keep the factory working at full capacity. According to a report by the United States Vice-Consul at Calcutta, there are now 2,514 acres under cultivation, bearing approximately 3,436,000 trees, from which 618,073 lb. of bark were harvested during 1917–18. The factory used during the year 654,093 lb. of bark, the average quinine percentage being 4·53, which would give a theoretical content of 29,630 lb. Actually, however, 29,417 lb. were manufactured, as well as 8,518 lb. cinchona febrifuge, 1,261 lb. quinidine, 930 lb. residual alkaloids, and 50 lb. cinchonidine.

Ipecacuanha has been growing on the Mungpoo plantation for many years, but until recently there was no encouragement to extend its cultivation. The experience of the last few years having shown the undesirability of relying entirely on external sources for supply of emetine, renewed attention has been given to its cultivation. There are now about 55,000 plants in stock, though it is a troublesome species to cultivate in the latitude of Mungpoo, and requires much care and time.

Digitalis purpurea is cultivated to a certain extent on the Mungpoo plantation, where about 30,000 plants were put out to provide leaf in the spring of 1919.

Chenopodium ambrosioides and *C. anthelminticum* were also put out in considerable quantities on the Mungpoo plantation to provide seed for extraction of the oil used in the treatment of hookworm disease.

Belladona cultivation has been commenced on quite a large scale at Mungpoo.

CORRESPONDENCE.

PROBLEMS OF FOOD AND OUR ECONOMIC POLICY.

Professor Henry E. Armstrong, in his third Cantor Lecture, made the following statement as reported in the *Journal* of September 19th:—

"Jams are no longer home-made, and in consequence either much over-boiled or over-sweetened to ward off moulds and bacteria. Too frequently they are sophisticated with inferior materials other than fruit."

My attention has been called to this by jam manufacturers who belong to the trade organisation of which I am secretary, and I shall be obliged, as the paragraph referred to casts a serious and unmerited slur on the jam trade, if you will allow me to place on record what I understand are the facts.

It may be that there are exceptions among the several hundreds of makers, but in factories fitted with up-to-date plant and machinery jams are not boiled longer than ten or eleven minutes, and in some instances less than this. It is on the contrary home-made jams that are generally over-boiled. Many good judges consider that it is impossible to over-sweeten jam, as if it is boiled to a proper consistency it should contain 25 to 30 per cent. of water. Jams will only keep good for a very short time unless they contain about 65 per cent. of sugar—itself, of course, a valuable food.

R. M. LEONARD, *Secretary*,

Jam Section of the Food Manufacturers' Federation.

Food Manufacturers' Federation,
9, Queen Street Place, E.C. (4),
October 7th, 1919.

Why are marrows sent from the south to Dundee? Will Mr. Leonard answer this riddle? Whatever the cause—over-boiling, over-sweetening, low average quality, and staleness of fruit or "sophistication"—much bought jam, of late years, has been sadly lacking in savour, in comparison with the properly "home-made" article. And there are certainly jams and jams on the market.

Unfortunately, in matters of food, public taste is not what it was, largely because of the elimination of the expert shopkeeper. Sir Ray Lankester, several years ago, I believe, in one of his delightful

talks in the *Daily Telegraph*, drew attention to the fact that everything tasted alike in the restaurants.

Having less opportunity of forming their taste under advice, the public are now poor judges and will swallow almost anything. The introduction of young women assistants into the larger shops has not helped matters—nor has it added to the amenities of shopping. Great public service will be done if more attention be paid to quality in food: indeed, this should be made the primary consideration, as savour and dietetic value probably stand in close relationship.

H. E. ARMSTRONG.

OBITUARY.

WILLIAM CARNELLEY.—Mr. William Carnelley, who had been a member of the Society since 1899, died on the 8th inst. at his residence in Manchester, at the age of ninety-six.

He was born in Barnsley, and entered the business of Messrs. Rylands and Sons. When the firm was converted into a limited liability company nearly fifty years ago, he became a director, and his active association with the house only came to an end three years ago. He was chairman of the company for many years. He was intensely interested in his business, in every department of which he was an authority, having worked as a spinner, dyer, weaver, book-keeper, cashier, salesman, buyer, director, and chairman.

JOHN CHARLES UMNEY, F.C.S.—The death of Mr. John Charles Umney took place on the 9th inst. at Yapton, Arundel.

Mr. Umney, who was born in 1868 and educated at Dulwich College and at the Pharmaceutical Society's School, was a leading authority on drugs, medicinal chemicals, and essential oils. He was largely responsible for the standards for medicines laid down by the Local Government Board, Ireland. He founded and edited the *Perfumery and Essential Oil Record*, by means of whose columns he stimulated the cultivation of aromatic plants and the distillation of oil in many parts of the world. He was at one time President of the British Pharmaceutical Conference, and of the Wholesale Drug Club, and Chairman of the Chemical Trade and Toilet Soap Sections of the London Chamber of Commerce. In 1912 he gave valuable evidence before the Select Committee of the House of Commons on Patent and Proprietary Medicines. He published various works, including "A Short Guide to the British Pharmacopœia," "Essential Oils in their Relation to the British Pharmacopœia and Trade," and "Standards for Medicines."

Mr. Umney was elected a Fellow of the Society in 1912, and in the following year he read a paper on "Perfumery," for which he received the Society's Silver Medal.

GENERAL NOTES.

INVESTIGATION OF MARKETS IN SOUTH AMERICA.—The Overseas Trade Department and the British Engineers' Association are despatching to Chile, Peru and Bolivia a joint investigator to ascertain the conditions and prospects for the sale of British engineering products in those markets. The subjects to be covered include imports, shipping methods, customs, tariffs, legislative regulations and restrictious, statistics and competition. The cost will be defrayed by the Association and the Government. Firms in certain specified categories who are not members of the Association are to be allowed to participate in the inquiry on payment before the receipt of the first report of a fee of twenty guineas.

COAL ECONOMY IN METALLURGY.—*Engineering* estimates the amount of coal consumed in our steel works at between forty and fifty million tons a year, and points out that every shilling per ton in the cost of this fuel means 4*s*. to 5*s*. on the price of steel. "Possibly half the coal which is consumed to produce steel at the present time could be saved, and although this is an ideal figure based on the production of steel in very large self-contained units, it is an ideal towards which all British manufacturers and metallurgists should strive, and towards which they will be forced to move by international competition. That our steelmakers are already alive to the means by which economies can be effected is shown by the large combinations of allied interests which have taken place during the past few months, and among the economies which will result not the least important will be the economy in coal."

AMERICAN SILK INDUSTRY.—According to the Silk Association of America, scarcity of labour is the most serious condition which the silk manufacturer in the United States has to consider. Immigration has been the chief source of supply of this kind of labour, but there has been no immigration since the war, and many foreigners are returning to their native lands, having saved enough from their "inflated war earnings" to enable them to establish themselves in comfort in their own countries. This condition also causes a shortage in semi-skilled and manual labour, where wages are triple those earned in former years. Silk operatives who became munition workers have attained a certain degree of knowledge and skill in the metal trades, and many are remaining in those industries. Female labour has grown "alarmingly scarce." With wages advanced in all industries, the wives and daughters of families do not find it as necessary to seek work, and the children are being kept at school longer. It would be interesting to know if, for similar reasons, children of the more highly-paid workers in this country are being kept at school longer.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—October 17, 1919.

No. 3492. OCTOBER 24, 1919. Vol. LXVII

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:

Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society of Arts

CANTOR LECTURES.

A full list of the Cantor Lectures which have been reprinted from the **Journal** and published separately may be obtained on application to

THE SECRETARY, John Street, Adelphi, London, W.C.

All communications respecting Advertisements should be addressed to the ADVERTISEMENT MANAGER, 97, GRESHAM STREET, E.C. 2.

Journal of the Royal Society of Arts.

No. 3,492. VOL. LXVII.

FRIDAY, OCTOBER 24, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COAL AND ITS CONSERVATION.

By William Arthur Bone, D.Sc., Ph.D., F.R.S.,

Professor of Chemical Technology at the Imperial College of Science and Technology, London.

Lecture II.—Delivered March 17th, 1919.

A NATIONAL POLICY OF COAL CONSERVATION.

Introduction.

Although coal is the world's most important fuel, and the principal source of its artificial heat, light, and power, it is far too valuable a material to be burnt indiscriminately by people ignorant of its true worth, as in the bad old days that are behind us. When suitably handled by the chemist, it is capable of yielding by-products—such, for instance, as naphthenes, benzols, tars, ammonia, etc.—whose values as raw materials for the manufacture of synthetic drugs and dyes far exceed their mere heat-producing powers when burnt in the ordinary way in our furnaces and fireplaces. Hence the chemists' objection to the burning of raw coal before it has been treated for the extraction of such by-products. My object in this lecture is to discuss what ought to be our national policy in regard to the utilisation of coal to the best advantage of the community as a whole. Such a policy will not concern itself so much with prolonging the life of our coal-fields as with getting the utmost "economic result" out of the coal we actually use. And by "economic result" I mean the maximum return in value for a given expenditure of capital and labour on the raw material operated upon.

If you will think over that definition you will see that I do not use the term "thermal efficiency." The thermal or power result is one of the many returns that can be got out of coal; but there are other considerations which enter into the problem besides that of thermal efficiency. In discussing this question, we want to get out of the way of talking only about thermal efficiency. It is a very important—in some cases the predominant—factor, but it is not always the deciding one. For instance, I have sometimes had to consider schemes for the production of power from coal or waste gases that have been thermally more, but commercially less, efficient than alternative schemes that have ultimately been selected; in such cases the final ground of decision has not been thermal efficiency, but the total result. This is not always sufficiently understood by so-called scientific people—in fact, commercial people often take a more scientific view of these questions than does the scientific man, because they look at more factors than he does. Therefore I want you to understand that the term "economic result" means the maximum return, for a given expenditure of capital and labour, from the raw material operated upon.

Inasmuch as immense quantities of coal must necessarily be consumed every day to maintain our social and industrial system, and also as the purposes for which they are consumed are various—such as, for instance, to generate power, to smelt iron, to make steel and other special alloys, to produce public supplies of gas, to warm our houses, and to cook our food—it behoves the nation to ensure that its available reserves of coal are used in ways that are calculated to fulfil such purposes to the best advantage, and that no individual or section of the community is allowed to use them wastefully. Now, paradoxical though it may seem, past experience has abundantly proved the truth of Jevons's dictum, that the more economy is practised in the use of coal, the more will its consumption increase, because, as he rightly said: "Economy multiplies the

value and efficiency of our chief material; it indefinitely increases our wealth and means of subsistence; and it leads to an extension of our population, work, and commerce, which is gratifying in the present, but must lead to an earlier end." Hence it follows that we must not expect to prolong the duration of our national coal reserves by using them more scientifically; we shall probably only hasten the end by so doing. The true object of national fuel economy should be to ensure that our coal is used to the best and the fullest advantage by every class of customer. For true economy lies not so much in using sparingly as in using well.

Before considering the application of this principle to our subject, I will direct your attention to the following estimate of our national consumption of coal in the year 1913:—

The Principal Uses of Coal in the United Kingdom in 1913.

	Million tons.
1. Mines and factories	80
2. Iron and steel and metallurgical industries	32
3. Manufacture of bricks, ceramics, glass, and chemicals	6
4. Railways and coasting steamers	17
5. Gas-works	19
6. Domestic purposes	35
Total	189

	Per cent. approx.
Power	40
Iron and steel works } Carbonisation }	27
Domestic	20
Transport	10

It is difficult to state exactly what is our coal consumption in a given year for each of the above purposes; but it may be said with a tolerable degree of accuracy that, before the war, the coal annually consumed in our mines and factories, chiefly for power purposes, amounted to about 80 million tons; in the iron and steel and other metallurgical industries, to about 32 million tons; for the manufacture of bricks, ceramics, glass, and chemicals, to about 6 million tons; for railways and coasting steamers, to about 17 million tons; in gas-works, to about 19 million tons; and for domestic purposes, to about 35 million tons a year. Or, in other words, for the purposes of power we consumed about 40 per cent of the total coal used in the Kingdom; in connection with iron and steel works and carbonisation (including gas-works and coke-ovens, which I bracket with iron and steel for a reason which will become apparent later), we used about 27 per cent.; for domestic purposes, about 20 per cent.; and for transport (including railways and coasting steamers), about 10 per cent.—leaving only a small percentage for other purposes. If we take power, metallurgical and carbonisation (which are closely allied), and domestic uses, we shall have accounted for nearly 87 per cent. of the whole of the coal consumption of the Kingdom. Upon these three classes of uses, I propose to concentrate in the remainder of these lectures.

Classification and Uses of Coals.

Before proceeding further, however, I would remind you that, when we use the word "coal," we are employing a term which is very comprehensive. It is really a generic term, comprising a great many different groups of raw materials—all of which have the same kind of origin, but each possessing its individual special qualities, as shown in the table on page 753.

Of these four great groups of coals, each of which (and especially I., II., and III.) may be sub-divided into a number of classes, the Sub-Bituminous (lignites and brown coals of Tertiary origin), have hitherto not attained to any great economic importance, because they are relatively low-grade, with high moisture (up to 50 per cent.) content, which has hitherto precluded their transportation over long distances. They are not found, to any large extent, in Great Britain, but occur plentifully in the Central European Plain (Germany and Austria), over large areas in the United States (Texas, Arkansas, and Louisiana; North Dakota, Montana, and Wyoming), in Canada (Alberta and Saskatchewan). Immense deposits of them (upwards of 300 ft. thick) occur in the province of Victoria (Australia), and there are also important ones in the Federated Malay States. The problem of how best to utilise lignites and brown coals is rapidly assuming first-rate importance, and for the Empire as a whole it is one of great and pressing moment. The famous Morwell brown coal of Victoria, one of the most wonderful stores of potential energy in the whole world, is being investigated by a Victorian Government Commission with a view to its utilisation on a big scale for the generation of electric power both for the Government railways and for the city of Melbourne. The Canadian Government has recently established a Lignite Utilisation Board, which is investigating the lignite of Alberta and Saskatchewan. The Americans are also busy with the problem.

CLASSIFICATION OF COALS.

	I.	II.	III.	IV.
GENUS OR GROUP.	Sub-Bituminous, including Brown Coal and Lignites.	Bituminous.	Semi-Bituminous and Anthracitic.	Anthracites.
GEOLOGICAL PERIOD.	Chiefly Tertiary.	Mesozoic Permo-carboniferous and Carboniferous.	Chiefly Carboniferous (? Some Permocarboniferous).	
PERCENTAGE "VOLATILES" YIELDED AT 900° C.	Above 45.	Between 18 and 40.	Between 8 and 20.	Below 8.
CHARACTER OF CARBONISED RESIDUE.	Non-Coherent.	A coherent "coke."	Non-coherent.	
PRINCIPAL USES.	(i) Distillation with Briquetting of Residue. (ii) Steam-raising.	(i) Coking. (ii) Gas-making. (iii) Steam-raising. (iv) Furnace purposes.	Smokeless steam coals, Admiralty Class.	Domestic Heating in Closed Stoves, Malting Kilns, etc.
REMARKS AS TO BY-PRODUCTS. RECOVERY ON DISTILLATION.	Often economical.	Always economical.	Rarely economical.	Never economical.

In my own laboratory we have been during the past seven years continuously engaged in investigating lignites from all parts of the world, including Italy, Australia, Canada, and the Malay Peninsula, chiefly with regard to their low-temperature distillation and the cognate problem of converting them, by the action of heat at a moderate temperature, into fairly good steam coals, a process which opens up considerable economic and commercial prospects. I want you to realise, however, that although to us in Great Britain lignites may seem to be an unimportant class, yet, from the point of view of world-economics, they are probably destined in the near future to play a vastly greater part than they have done hitherto, both in regard to low-temperature distillation and for power purposes.

The Bituminous Group of coals, of which there are many sub-divisions, constitute the greater, and by far the most important, part of the world's total reserves. Those yielding, say, between 18 and 32 per cent. of volatile matter (when carbonised at 1000° C.) are chiefly used for the manufacture of hard metallurgical coke; next come the "gas coals" (volatiles = 32 to 40 per cent.), which yield a weaker coke but a larger volume of gas than the "coking coals" proper; finally, there is a class of non-coking "long flame" coals (volatiles = 40 to 45 per cent.), which used to be employed extensively for reverberatory furnace work. "Steam coals," of varying volatile contents, are also found in this great group. Next in order comes the Semi-Bituminous or Anthracitic Group of non-caking coals (volatiles = 8 to 20 per cent.) which constitute the finest of all steam-raising coals, being smokeless (or nearly so) in their combustion; the famous South Wales Admiralty steam coals belong to this group. Finally, we have the anthracites proper (volatiles less than 8 per cent.), which are chiefly used for domestic heating in closed stoves, for the firing of malting kilns and the like.

There are one or two outstanding points in connection with such a classification to which I would direct your attention for a moment. First of all, what is termed the "coking properties" of a coal seem to depend very largely upon the amount of "volatiles"

which it yields on carbonisation at (say) 900° to 1000° C. Practically all coals yielding less than 15 or more than 40 per cent. of "volatiles" are non-coking; the coking properties suddenly (as it were) appear when the "volatile yield" reaches a point somewhere between 15 and 18 per cent., and are at their maximum when it is between 18 and 30 per cent. Beyond this limit, the coking properties fall off rather rapidly, and finally disappear altogether when the "volatile yield" exceeds 40 per cent., and sometimes even below that limit. But whilst the coking properties may thus be connected empirically with the "volatile yield," we do not yet really understand their cause, and still less can we tell why they seem to arise so suddenly when the "volatile yield" reaches a point somewhat above 15 per cent., and then attain so rapidly their maximum degree. This is a matter upon which further research is greatly needed.

Again, within each of such groups and classes it is necessary, from an economic standpoint, to *grade* coals according to their ash-contents. Only such coals as contain less than a certain proportion of ash can be regarded as "high-grade"; and when the ash-content is unduly high, then, although its "coal substance" may have the right properties, it is rendered unsuitable for coking or gas-making purposes. In many such cases, coal washing may be successfully resorted to as a means of eliminating a large proportion of the excessive mineral matter, but there are also cases where such separation would not pay.

Finally, there remains another important consideration to which I must, at this point, refer. Sometimes bituminous coals are encountered which are so soft in texture that, when they are removed from the seam, they have very little marketable value, although they may be very good coals for distillation purposes. These coals, if they are to be used at all profitably, must be consumed in the neighbourhood of the colliery. Otherwise, their value at any great distance away is small, inasmuch as they will not stand transport. So we have to solve the problem of dealing with coals which, although they may be very suitable for certain commercial purposes, are nevertheless of too soft or friable a nature for transport.

The Need of a "Free Trade" National Coal Research Policy.

It will thus be realised how many complex factors, arising out of the nature of the coals themselves, must be taken account of in framing a national coal policy. Also, there are many fundamental problems connected with the chemistry of coal itself that must be attacked before such a policy can rest on a really scientific basis. This is why I so strongly advocated, both in my Presidential Address to the Chemical Section of the British Association at Manchester in 1915, and also in my lectures before the Royal Institution in the following year, the undertaking, with the aid of public funds, of a "systematic chemical survey" of our British coal-fields. And I accepted service with the Fuel Research Board in 1917 in the hope that such a survey would be inaugurated by it on broad and adequate lines. Unfortunately, however, I soon realised that my hopes were not likely to be fulfilled. And here I feel it my duty to say that, in my opinion, the problem is such as will require the co-operation of all the best available minds and resources in the country, and that it will never be solved by bureaucratic methods or by any over-centralised policy which (whatever its intent) would, in effect, tend towards creating a monopoly of research on stereotyped lines. In the national interests, I have always advocated a policy of "free trade" in coal research, because I feel that the most vital requirement is a broadly-planned policy which will aim at stimulating and assisting experimental work on the chemistry of coal, fuel economy, and cognate subjects everywhere throughout the whole Kingdom; and I am opposed to anything which would tend to sterilise fuel research, or develop it along too exclusive lines. I trust that chemists and the public generally will see to it that a more enlightened policy prevails in the future.

Fortunately, our British available coal reserves, though quantitatively small, are for the most part qualitatively of the best, and moreover they are well situated both in regard to our ports and to our iron ore deposits. Also they are unusually well-varied in their qualities. Thus, in Durham we have perhaps the finest "coking" coal seams in the world; in Yorkshire and Derbyshire, some of the best "gas coals"; in South Staffordshire, good "furnace coals"; while the South Wales semi-bituminous steam coals are famous throughout the whole world. It seems as though Providence has put down in this little island of ours a great variety of materials and that we are intended as a race to discover, invent, and pioneer things. This is one reason why this country has been so favourably situated for pioneering new industries. We

have within our borders a great variety of raw materials, and this applies particularly to coal.

Having regard to the nature and variety of our available coals, and the paramount importance of our coal-export trade, it seems to me that the policy along which the commercial development of our coal-fields ought to proceed should aim at (*a*) retaining for our own use the best "coking" and "gas" coals, but (*b*) in regard to "steam coals," to export the best grades and to generate the power required for our home industries, as far as possible, from low-grade coals. This is one reason why I have supported the idea of co-operative electric power-supply from large central stations, because it affords perhaps the best means of utilising our low-grade steam coals. This is likely to become a more pressing economic question as the development of our coal-fields proceeds.

The Proportion of the National Coal Output that Should be Carbonised.

Coal is so valuable a material that we ought as far as possible to avoid burning it in the raw state; but in our present state of industrial development it is difficult to realise this ideal. We ought always to aim at the recovery of valuable by-products. Certainly, the world's industrial development is already so far advanced that we can say that all coals intended for use in the smelting of iron and steel and in gas-making, and I hope in the near future also for domestic consumption, should be carbonised in some way or other before use.

Uses of Coal in which Complete By-product Recovery is, or should be, possible.

Coking (iron and steel works). Gas-making (gas works) . . Domestic	Say, 45 per cent. of the nation's total consumption.

In 1913 we actually carbonised—

10 per cent. in gas works 7 ,, in coking plants	= 17 per cent.

If we take the consumption of coal in the United Kingdom for the three purposes named, we find that it is 45 per cent. of the whole. So that we ought now, or in the near future, to be able to carbonise some 45 per cent. of our total consumption. I find that in 1913 we carbonised approximately 10 per cent. of the coal in gas-works, and about 7 per cent. in by-product coking plant, or a total of 17 per cent. only. We might have carbonised about 25 per cent. Certainly we ought soon to realise more than this figure, in view of the possibility of carbonising part of our domestic supply.

A partial recovery of by-products ought also to be possible in regard to the coal consumed for power purposes. It should be our object in investigation or research to try to expand the possibilities of by-product recovery in regard to certain classes of our coal that are used for power production. I do not say we shall find it possible, or even desirable, to carbonise, either partially or completely, all the coal required for power production. I am not putting forward an ideal like that. We are not yet far enough developed; but at present we ought to be devoting ourselves to investigating the possibilities in that direction.

Let us consider what we are likely to get out of coal carbonised at a low temperature. I mean by "low" a temperature between 500° and 600° C. If we carbonise at this temperature, we ought to select a coal that will give a residue which is either naturally coherent or which can easily be briquetted under pressure. We shall obtain from it, as a rule, about 70 to 80 per cent. of its weight of what I call "semi-coke." This "semi-coke," if it could be prepared in a condition that would stand transport and distribution, would be an excellent fuel for burning in household fireplaces. Then there is a comparatively large amount of condensable tars or liquid products. These products would consist chiefly of what the chemists call the naphthene series of hydrocarbons. There is here one very important difference between low and high temperature carbonisation. You have all heard how the benzols and toluols (the benzol hydrocarbons) have played an extraordinarily important part in the war. We derive from them the high explosives which we have used so effectively in the war. They are also the basis of coal-tar dyes; and we also prepare from them a number of synthetic drugs, disinfectants, etc. These valuable hydrocarbons are not found in the tars produced at low temperatures. According to investigations made in my own and other laboratories, low-temperature tars are mainly composed of hydro-benzols. These, and not the benzol hydrocarbons, are the chief constituents of the tars produced in low-temperature carbonisation; and the amount is about 6 to 10 per cent. of the weight of the coal, according to the kind of coal. In addition, a small amount of fairly rich gas is obtained, varying with English coals from 2,500 to 4,000 cubic ft. per ton, or more in the neighbourhood of 3,000 cubic ft. than any other

figure. This gas is very rich in paraffin hydrocarbons—methane, ethane, etc., but it contains only a small proportion (less than 15 per cent.) of hydrogen. One other important point I must not forget. At such low temperatures we do not get much ammonia. It would not amount, as sulphate of ammonia, to more than between 6 and 8 lb. per ton of coal.

Commercial Prospects of Low-temperature Carbonisation.

The chief difficulty about the wider adoption of low-temperature distillation is a commercial one. The prospects would be decidedly good if only a good "semi-coke" which will stand transport could be produced. Another difficulty is that the present commercial value of the tars is not great. The naphthenes could be used as motor spirit and fuel oil. But they cannot be made the basis of coal-tar dyes, unless indeed they are cracked; and then the coal might just as well be distilled at high temperature straight away. It is quite possible technically to carry out the low-temperature process; but the commercial prospects have so far not been very encouraging, although changing circumstances may favourably affect them. I for one hope to see the day when low-temperature carbonisation will not only be more technically perfect than it is now, but also when the commercial prospects of it will be better. And there are already signs of that day arriving perhaps more quickly than some people think. I myself have quite an open mind on the subject, and think that possibly some "intermediate" temperature (say *circa* 700° C.) may be found to yield a sufficiently good combination of results to make it an attractive commercial proposition.

At any rate, it seems worth trying, in view of the need of a "smokeless" domestic fuel and of larger supplies of motor spirit and fuel oils generally.

High-temperature Carbonisation.

Let us now consider carbonisation at high temperatures, by which I mean at temperatures from, say, 900° to 1100° C. If a suitable coking coal is chosen from among the hard coking series a hard metallurgical coke is produced. Also benzene, toluene, benzenoid and phenolic tars, plus a considerable amount of ammonia, are obtained. The resulting "coal gas" also contains a number of constituents, the nature of which we shall discuss later on. High-temperature carbonisation has been carried out in this country on a large scale for about a century, and is so well-established an industry that its prospects do not require talking about, because they have already been realised. Now the important question arises: how, in the public interest, should this process of high-temperature carbonisation be carried out in future, and what should be aimed at in regard to public gas supplies? I therefore propose to discuss one or two changes that may possibly come over the carbonising situation. We are at present in a state of transition or flux. A great many competent people are thinking about carbonisation problems, and what our future policy should be. They do not all agree; and I may have to refer to proposals with which I do not personally agree. But I think it right to give you as far as possible not only an unbiased, but a reasoned, statement of the pros and cons of the various suggestions that have been made.

When the best types of British "coking coals" are carbonised in coking chambers, with by-product recovery plant attached, for the manufacture of hard metallurgical coke, there are usually obtained:—

		Percentage of weight of dry coal.
Coke	between	67·0 and 75·0
Tar	,,	2·5 and 4·0
Benzols	,,	0·6 and 1·4
Ammonium Sulphate.	,,	1·0 and 1·4

Surplus Gas: between 3,000 and 5,000 cubic ft. per ton.

The "debenzolised" gas contains:—
$CO_2=2 \cdot 5$, $CO=6 \cdot 5$, $C_nH_m=2 \cdot 0$, $CH_4=25 \cdot 0$, $H_2=55 \cdot 0$, and $N_2=9 \cdot 0$ per cent.
and its gross calorific value, per cubic foot at 15° C. and 760 mm., is approximately 485 B.Th.U.s.

When "gas coals" are carbonised in gas-works retorts, similar products are obtained, the chief difference being that the coke yielded is inferior, both in quality and quantity, to that obtained in coke ovens, whilst the gas is richer and more abundant. Also, whereas coke ovens are fired by a portion of the "debenzolised" gas (about half of it is so required), gas retorts are heated by "producer gas" generated in the setting from part of the coke produced. Thus, for example, a good Derbyshire gas-coal yielded, when carbonised at about 1000° C. in horizontal retorts:—

Coke = 63·0 per cent. of the weight of the coal charged.

(N.B.—About *one-eighth* part of this coke was used to fire the setting.)

Tar = 10·5 gallons (sp. gr. = 1·19) per ton of coal.

Ammonia Sulphate = 28·5 lb. per ton of coal.

Gas = about 12,000 cubic feet, at 15° C. and 760 mm., per ton of coal.

The gas contained:—

$CO_2 = 2{\cdot}60$, $CO = 5{\cdot}20$, $C_nH_m = 3{\cdot}30$, $CH_4 = 34{\cdot}00$, $H_2 = 43{\cdot}50$, $N_2 = 11{\cdot}40$ per cent.

Its calorific values would be about 590 (gross) and 520 (net) B.Th.U.s per cubic feet at 15° C. and 760 mm.

If the heat balance of such a process were investigated, it would be found that, after deducting the coke required for firing the setting, the potential energy of the residual coke available for sale would be about 50 per cent., of the gas about 25 per cent., and of the tar about 5 per cent., that of the coal carbonised. In other words, the thermal efficiency of the process would be about 80 per cent., which, it must be admitted, is a very satisfactory result. Indeed, it has been stated that the two Metropolitan Gas Companies, which in the year 1913 carbonised 3·114 million tons of coal (or about one-fifth of the total carbonised by all the authorised gas undertakings in the Kingdom), actually sent out of their works, in the form of coke, gas, and tar, a little more than 70 per cent. of the potential energy of the coal taken into them. The gas actually sold accounted for nearly 25 per cent. of the total energy of the coal employed in making it. It would thus appear that, taking the process as a whole, the thermal efficiency is commendably high.

Nevertheless, many competent judges are of the opinion that the time has come when gas-works ought to send out a much greater proportion of the potential energy of the coal in the form of *gas* than they have hitherto done, and the endothermic interaction between steam and incandescent coke, productive of "water gas," is readily available for such purposes. In other words, a combination of "carbonisation" and "water-gas" processes is now advocated as a means of increasing the proportion of energy sent out in the gas, at a corresponding sacrifice of part of that hitherto made available in the coke.

Steaming Vertical Retort Charges.

Investigations have been made with the object of trying the effect of introducing steam under pressure at the bottom of the vertical retort during carbonisation. The idea is, of course, to utilise the heat in the incandescent coke to generate water gas; and this gas passing upward materially assists in the distribution of heat in the retorts. These steaming experiments have been highly successful, and it is probable that the practice of steaming the charges in vertical retorts will become common. I may quote the results from one series of experiments.

Steaming of the Charge.

[Steam introduced at 40 lb. pressure through a $\frac{1}{8}$-in. nozzle.]

Result: 16,600 cubic ft. of gas per ton (instead of 14,000 cubic ft. without steam).

Percentage Composition—

CO_2	CO	C_nH_m	CH_4	H_2	N_2
3·7	17·1	2·2	20·0	57·2	5·0

B.Th.U.s in gas per ton = 8,386,000, or, say, 28·0 per cent. of the potential heating value of the coal.

The coal used normally gave 14,000 cubic ft. of gas per ton. Steam was introduced at 40 lb. pressure through a $\frac{1}{8}$-in. nozzle; and the result was that the gas production went up to 16,600 cubic ft.—or an increase of 2,600 cubic ft.—containing some 20 per cent. of methane, 57 per cent. of hydrogen, and 17 per cent. of carbonic oxide. In the ordinary carbonisation process, the potential heat in the gas was about 23 per cent. of that of the coal. By steaming, this was increased to 28 per cent., at the sacrifice of some of the coke. If it is desired to get more heat units into the gas, then this policy of steaming retorts is to be commended.

Effect of Gasifying the Whole of the Coke.

There is, however, a further possibility to consider. Many people believe that, instead of our gas undertakings selling both coke and gas, as heretofore, it would be better for them to gasify the *whole* of the coke in a water-gas generator, and to send out, through the public mains, a mixture of blue-water gas and coal gas. In this way, there could be produced, and sent out from the works, about 50,000 cubic ft. per ton of coal of a "mixed gas" of somewhat the following composition:—

$CO_2 = 3{\cdot}5$, $CO = 35{\cdot}0$, $C_nH_m = 1{\cdot}0$, $CH_4 = 7{\cdot}0$, $H_2 = 50{\cdot}0$, and $N_2 = 3{\cdot}5$ per cent.

Its calorific values would be 370 gross and 320 net B.Th.U.s per cubic foot at 15° C. and 760 mm.

Looked at from the standpoint of thermal efficiency, the total energy sent out in the form of gas from such a works would now be about 57 per cent. of that in the coal taken in, or, say, about 62 per cent. if the thermal value of the tar produced were included in the balance. The

adoption of such a plan, whilst it would involve a very considerable gain in regard to the proportion of the coal energy sent out as gas, would mean, on the whole, a marked diminution in thermal efficiency as compared with present practice. But its advocates claim that, inasmuch as gas can be burnt with greater efficiency than coke, the public would be the gainer by its adoption. Also, they aver that the public would get heat units in the form of gas more cheaply than they would otherwise get them under a continuance of the older practice.

FUTURE STANDARDS OF PUBLIC GAS SUPPLIES.

It is, however, manifest that were such proposals as the foregoing to be adopted, either wholly or in part, the whole question of the "standards" of public gas supplies would have to be reviewed and radically altered. The public would in future be supplied with a practically non-luminous gas of much lower calorific value, but somewhat higher calorific intensity, than that to which they have hitherto been accustomed. And, also, the new gas would, on account of its high CO and low CH_4 contents, not only be more poisonous, but also have a wider range of explosibility with air, than the old-fashioned coal gas. It would indeed be a totally different kind of gas, and possibly the British public would not take kindly to it, in which case the business of the gas industry would undoubtedly suffer.

A very important proposal has recently been put forward by Dr. Charles Carpenter, the Chairman of the South Metropolitan Gas Company, namely, that in future gas shall always be sold on a thermal basis only, and that the consumer shall be charged, not so much per 1,000 cubic ft., as hitherto, but so much per 100,000 B.Th.U.s supplied to him. Let us see how this is likely to work out.

It may be at once admitted that this new proposal* has many advantages, and, on the face of it, it is eminently fair. The consumer will know what he is buying, and the undertaking supplying him will no longer be able to charge him for a lot of "inert" gases that, under the present system of charging by "volume," are often sent out in the gas. It would no longer be possible for gas managers to draw air through their retorts with a view to increasing their gas yields and revenues, and gas undertakings would not benefit, but rather lose, by such questionable practices. From this point of view, I like Dr. Carpenter's proposal.

There are, however, certain objections—I do not say fatal objections—to it, which ought to be considered at this stage. In the first place, the new proposal seems to involve another proposition, namely, that the economic value of a gas can be referred to a purely thermal basis, irrespective of its chemical composition and of the concentration of the energy in it. It brings to mind an expression, coined in the gas industry, that "*one B.Th.U. is as good as another*." With a person who is unfamiliar with the chemistry of combustion, such a plausible expression may find favour; but no chemist who views the matter from an independent standpoint, in the light of present-day knowledge, is likely to subscribe to it, and I venture to deny it. Time does not permit of my examining this popular dictum as thoroughly as I should like, but I will, as briefly as possible, indicate some of the grounds of my objection to it.

First of all, taking the question of "concentration," I venture to think that it is not altogether a matter of indifference to the community whether the public mains are used to convey a gas of, say, 600 or of 400 B.Th.U.s per cubic foot. And if I want to feed a large furnace, it matters a good deal which of the two gases I am supplied with. Also, I am prepared to advance, if need be, a number of valid reasons, proved on scientific investigation and supported by practical experience, why the chemical composition of a gas, as well as its thermal value, is of importance to a consumer.

Next, let us consider the matter for a moment from the standpoint of public safety and convenience, remembering that whoever uses gas has to burn, not gas alone, but an explosive mixture. It would be foolish to frame a policy on the supposition that gas is used by scientific and technical people only. On the contrary, it is mainly used by a great variety of inexpert people, from Mary Jane in the kitchen upwards. And when such people have to use cooking and heating appliances involving the burning of explosive gas and air mixtures, it is necessary that the conditions should be rendered as safe and fool-proof as possible for them.

From this point of view, it is important to compare the properties of the three chief constituents of coal gas and water gas, namely,

* Since the lecture was delivered, the proposal has been recommended by the Fuel Research Board to the Board of Trade (Parliamentary Paper Cmd. 108); it has also been reviewed by the British Association Fuel Economy Committee in their Second Report, published in September, 1919.

methane, hydrogen, and carbonic oxide, in somewhat the following manner:—

COMPARISON BETWEEN METHANE, HYDROGEN, AND CARBONIC OXIDE.

	Methane.	Hydrogen.	Carbonic Oxide.
Gross and Net Calorific Values B.Th.U.s per cubic foot at N.T.P.	1064 951	843 287	341
Range of Explosibility of Mixture with Air —% Gas	5·6 to 14·8	4·1 to 71·5	12·4 to 73·0
Relative Radiation from Flames	4·4	1·0	2·4

Thus it will be seen (1) that a cubic foot of methane represents about three times as much potential energy as a cubic foot of either hydrogen or carbonic oxide; (2) that methane has a very much narrower range of explosibility with air than either of the other two; and (3) that there are wide differences between the "radiating" powers of their flames. Moreover, in small pipes (2 to 3 in. diameter) the rate of propagation of flame through the most explosive mixture of methane and air is comparatively small (not greater than 100 centimetres per second); on the other hand, the most explosive hydrogen-air mixture will propagate flame at the rate of 500 centimetres per second. Lastly, whilst it is very difficult (some would perhaps say impossible) to set up "detonation" in methane-air mixtures at the atmospheric pressure, it is comparatively easy to do so in hydrogen-air mixtures, which readily develop dangerous explosions. If the advocates of the new proposal are prepared to argue that it is a matter of indifference whether or not the gas supplied to the public has a wide range of explosibility or not, I must beg leave to disagree with them, and to stipulate that it should contain a certain minimum proportion of methane in order to render it safe and convenient to be handled by ordinary people.

Or again, let us compare the properties of hydrogen and carbonic oxide, which in this connection have a peculiar interest because their calorific values per cubic foot are nearly the same. Therefore, some may say, it is immaterial whether a consumer is supplied with one or the other of them. Wait, however, until he has an escape, and it may make all the difference between this world and the next for him according to which of the two he has. Or, supposing his pipe system is immune from such an accident, and that he is using the gas either for furnace purposes or in a gas engine, he will soon find out that, on account of its superior "radiating" power and slower rate of flame propagation, carbonic oxide is far preferable to hydrogen for such purposes. Indeed, any steel-works manager will tell you that whilst he wants the producer gas supplied to his open-hearth furnace to contain a large proportion of carbonic oxide, he would object to the presence in it of more than about 12 per cent. of hydrogen. Also, in running large gas engines for power generation in connection with iron and steel works, we know how much better they work on a gas whose combustible constituents are mainly carbonic oxide than on one correspondingly rich in hydrogen. And I venture to think that anyone who has closely studied the modes of combustion of the two gases will also come to the same conclusion.

I therefore put it to the gentlemen who are propounding these problems for us, that it is not true to say it is a matter of indifference as to how the potential heat units are present in a public gas supply; and that the cumulative results of scientific research, supported as they undoubtedly are by practical experience on large-scale working, prove that the fundamental properties of the explosive mixtures formed by different combustible gases with air, arising from their own chemical properties and modes of combustion, do affect profoundly their uses for power and heating purposes. Moreover, in regard to a domestic gas supply, I would add that public safety and convenience alike require that it should not be allowed to contain more than a certain maximum proportion of carbonic oxide and less than a certain proportion of methane; and I would suggest provisionally that these limiting proportions might well be fixed at 20 per cent. in each case.

In conclusion, I would like to urge that a question of such moment should not be finally decided without reference to some *ad hoc* committee, specially set up for the purpose, which shall be representative of the ablest and most experienced scientific men and technologists who have specially studied carbonisation, gaseous combustion, and industrial heating problems, many of whom have as yet had no opportunity of expressing their views on the matter. And considering that there is no great urgency about it, I deprecate any undue haste in coming to a decision, and especially any attempt to "rush" through legislation, or even departmental regulations on the subject, before all parties (and particularly those representing the general consumer) have been fully heard.

I am decidedly of the opinion that the gas industry ought not to be allowed an unrestricted freedom, which some of its extreme partisans apparently desire, with regard to the quality and composition of the commodity which it supplies, and that its voice ought not to predominate in the matter. It has rightly set up and maintained its own committees to investigate and report upon its problems; but whilst their findings will command respectful attention, public policy requires that they shall not be accepted without reference to some quite neutral tribunal. For it is the public interest, and not that of the industry, which must predominate in the final settlement of all such questions. I believe that great changes in the present methods of manufacturing gas are both necessary and inevitable, and that, subject to the modifications and safeguards already indicated, Dr. Carpenter's proposed reform in regard to the selling basis of gas is one which, in principle, might well be adopted.

TOBACCO INDUSTRY IN THE DOMINICAN REPUBLIC.

After cacao, tobacco is the principal crop in the northern half of the Dominican Republic, ranking third in the list of exports from the country, sugar being first. The leading tobacco-growing provinces are Santiago, Puerto Plata, La Vega, and Espaillat. The town of Santiago de los Caballeros is the centre of this industry, where most of the tobacco is brought in to be sorted and repacked, and Puerto Plata is the port through which most of it is exported. Moca, in the Province of Espaillat, La Vega, the capital of the province of the same name, and Navarrete, in Santiago, are also important centres of the tobacco trade. It is estimated that about 75 per cent. of the crop is grown in the Province of Santiago, and 15 to 20 per cent. in Puerto Plata, and the remainder is about equally divided between La Vega and Espaillat.

It is a local custom in this region, writes the United States Consul at Puerto Plata, to sow tobacco seeds on St. Andrew's Day, November 30th. The seedlings are usually transplanted in January, sometimes in rows, but often without any regard to symmetry. If weather conditions are favourable, the crop should be harvested in March and April, before the heavy rains commence. The exporting season is from July to October inclusive.

The usual mode of packing tobacco in Dominica is in seroons made of palm bark and matting made of leaves, each weighing about 110 lb. net and 120 lb. gross. The present packing is not, however, considered satisfactory. It is said that the best and most practical manner of packing in this region is in canvas bales, lined with dried palm leaves; but this method is seldom practised.

The tobacco crop is usually bought from the growers through brokers who work for packers or exporters in the towns, charging them half a dollar per bale commission. The buying and paying is done at the barns of the growers. The tobacco comes in from the farms in strings, known as "sartas," and is then bunched by women in "hands" according to lengths. It is repacked in new seroons, headed in with palm, and tied over the mouth with native fibre twine. The cost of handling thus described is usually about $2 per seroon, but this varies with the constantly fluctuating price of the materials used in packing. In some instances the buyers advance money to the growers through the brokers, charging them from 2 to 4 per cent. interest per month. The farmer usually sells his tobacco to the broker by the seroon, all qualities being mixed.

There are two types of tobacco, one known as "criollo," the other as "tabaco de olor," which latter is made into cigars and cigarettes for domestic consumption. The type known as "criollo" usually comprises about 80 per cent. of the crop.

On the arrival of the seroons from the country they are opened, graded, and repacked by the packers. There are three different grades: "A," filler; "F," binder; "FF," wrapper. These grades refer to the size rather than to the quality of the tobacco. When the crop is very good there is also another grade, consisting of very large leaves, known as "superior."

Prior to the war the tobacco industry was controlled by German firms in Bremen and Hamburg. They advanced money to the packers, and the latter through brokers to the farmers. The prices obtained were so low that they hardly covered the cost of production. Owing to the low prices, Dominican tobacco has always been in demand in Europe. It does not enter into competition to any extent with the American, but may be compared in quality and uses to Brazilian, Sumatra, and Colombian tobaccos. Almost the entire crop was shipped formerly to Bremen and Hamburg, where some was re-packed and classified, and much was re-shipped as it arrived. A large quantity was consumed in Germany, and most of the remainder was re-exported to Austria, France, Spain, Italy, Algiers, Sweden, Holland and Switzerland. It is used in Europe chiefly as a pipe and cigarette tobacco.

The bulk of the tobacco is now purchased and exported by an Italian firm in Puerto Plata and two American houses in Santiago de los Caballeros. Since the war most of the tobacco has been shipped by these houses, either direct or through New York to Spain, France, Italy, Algiers, Holland and Switzerland. It seems probable that in future Dominican tobacco will continue to be shipped directly to the consuming markets of Europe instead of through Bremen and Hamburg, as formerly.

There are no large or scientifically managed tobacco plantations in the Dominican Republic. The average farm has from three to four acres under

cultivation. A few farms have up to fifty acres, but they are the exceptions.

The methods of cultivation, curing and packing are most primitive. Seed is sown by hand as machinery has not yet been introduced. Most of the cultivation is done with the machete, and very few ploughs or other implements are employed. Tobacco is not grown under shade, neither is the land fertilised. Drying-houses are not closed as in other countries, but are exposed to all conditions of weather. Too many leaves are strung together, and fermentation is not conducted scientifically.

Practically all of the tobacco farms are owned and worked by Dominicans. It is said that more branches of native labour are employed in the planting, harvesting, and shipping of tobacco than with any other crop, and that the proceeds are more widely distributed among the people.

The average yield in recent years has been about 200,000 seroons of 110 lb. each net, although it is estimated that the growing region of this island is capable of producing at least 1,000,000 seroons annually. It is said that if better methods were employed Dominican tobacco would equal that grown in Cuba and Porto Rico.

A great stimulus has recently been given to the Dominican industry by the high prices prevailing, and by the fact that the growers are no longer being exploited by German tobacco speculators. It is confidently expected, concludes the United States Consul, that the tobacco crop of the island will improve rapidly in quality and increase in quantity, and that it will not be long before the Dominican Republic becomes one of the leading tobacco-producing countries of the world.

BANANA-GROWING IN COLOMBIA.

The banana crop is much the most important of the Santa Marta district of Colombia. About 150 plants are set out to each hectare (2·47 acres). Plants mature and produce in from six to eight months' time. Each plant bears one bunch of fruit and is chopped down, the new ones bearing in rotation and making a continuous crop. The average production is fifteen bunches of fruit per hectare weekly, or 780 bunches per hectare per annum. At a minimum price of from 1*s*. to 2*s*. per bunch, the average annual gross return is £58 per hectare. From this gross return must be deducted the cost of cutting, carting to railway, and the price of the land in the banana district, *i.e.*, land suitable for bananas, subject to irrigation, and near railway. The value of this land is from £5 to £10 per hectare; all the good land available in the district is now taken up and under cultivation, with the exception of some holdings of the United Fruit Company used for cattle land.

According to a report by the United States Trade Commissioner at Santa Marta, the cost of clearing one hectare of raw banana land—virgin forest and brush—in that district is approximately £4 per hectare, the land not being stumped but simply slashed and burned off, the large trunks and stumps rotting away in from four to five years' time. To this must be added the cost of diverting the water from one of the streams in the district and the irrigation-ditch system of the land itself, which necessitates engineering work. Thus the total cost of one hectare of banana land in production, including administration and upkeep expense, transport and cartage facilities, and interest on the investment, is calculated in the Santa Marta district at from £50 to £60. Producing lands have been sold at prices ranging from £50 to £80 per hectare. Banana plantations twenty-five years' old are still producing as well as ever with no signs of exhaustion of the soil.

Irrigation is necessary on account of the insufficient rainfall, which does not exceed eighteen inches annually and is subject to extreme variation. There are also dry years when there is practically no rain. The same is true of the entire region of the Goajira Peninsula and the north coast of Colombia.

The rivers of the district from which water is taken for irrigation of banana lands are the Manzanares, La Gaira, Toribio, Cordoba, Frio, Orehueca, Sevilla, Tururinca, Aracataca, Fundacion. All of these rivers are small streams coming down from the Sierra Nevada, and judging from their appearance last December, after a protracted dry season following a year of little or no rain, they carried little more water than is needed for the banana lands now under cultivation. The soil is all very loose and soft, and the work of ditching is easy and inexpensive.

The business would seem to be a very profitable one judging from the cost and the production returns, but there are several speculative features, viz., the perishable nature of the fruit, which a few hours of sun will ruin for export; dependence on shipping facilities; and destruction of crops. While no disease has appeared such as has devastated banana plantations and entire districts in Central America, the Santa Marta district suffers frequently from high winds, which blow down entire plantations in a few hours. When this happens the large plants have to be cleared away and production is suspended until the smaller plants begin to bear.

There are some 300 private planters in the district, who are under contract with the United Fruit Company, according to the terms of which the company is obliged to take their fruit first. On account of the scarcity of tonnage during the war, the United Fruit Company has been taking contract fruit from the private growers and allowing its own plantations to lie idle. The 16,000 acres owned and operated by the company have been kept up during the war, but the fruit has gone to waste.

Private growers under contract with the United Fruit Company admit that they have received a handsome return for their investment, even under war conditions, and it was said that a profit could be made with a price of 7*d*. per bunch.

There is sufficient labour in the district for all of the plantations now bearing, including those of the United Fruit Company when these are being cut. The average wage per day for banana labourers is 3*s.* 3*d.*, and the work, with the exception of ditching, is well adapted to the native liking and disposition. The United Fruit Company maintains a corps of engineers who lay out and construct the ditch systems for the company and also for the private growers.

Oxen are used in preference to mules for draught animals in the banana plantations, as they stand the heat better and are more suited to the soft, wet ground. Two-wheeled carts carry the fruit to the loading switches on the railway. "Ceibu" bulls are imported to cross with the native strains, the result being a breed free from ticks and heavier in beef than the native cattle, although the size is not much increased.

WASTE IN MOVEMENT STOPPED.

The *Times* draws attention to an interesting experiment in reducing effort and at the same time increasing output, which was undertaken recently at the Derwent Iron Foundry, Derby, and is described by Dr. Myers in a report to the Industrial Fatigue Board.

In May, 1915, the iron foundry began to work for the Ministry of Munitions. Its estimated capacity for the articles produced was 3,000 weekly. Mr. Jobson, the managing director, began in August, 1915, to apply new methods, and these were so successful that by August, 1918, the output was 20,000. During the period August, 1916–1918, the value of output increased fivefold, though the price paid by the Ministry had been reduced meanwhile by 13·3 per cent.

The methods employed to obtain this startling success were as follows: Mr. Jobson approached his employees with the statement—"We are out for higher wages, less hours, and more output. Will you help us? Are you willing to have your movements studied so that we can find out the best way, adopt this as standard, and cut out useless and unproductive movements?"

The study of movements, and the training based on that study, were then begun. The movements were examined in various directions.

1. Various jobs were analysed to their elemental units, and each action was followed with a stop-watch in order to arrive at the best and quickest method of performing it.

2. Tools and materials were arranged in a standard manner, and thus all unnecessary movements to obtain these were eliminated.

3. A standard set of movements for each process was established, with a standard time for the employment of each.

4. Such movements as could be performed simultaneously were combined.

During training typewritten instructions in each movement, with times necessary for its accomplishment, were given to each student. The number of elements standardised in the process of moulding alone ran into hundreds. Men were trained individually rather than in groups. As soon as training was begun the hours of work were reduced from fifty-four to forty-eight per week. Instead of starting at 6.30 a.m. the employees started at 8 a.m., and worked till 5.45 p.m., with an hour's interval.

It was argued that a man who produced a greater number of pieces is entitled to a higher price per piece, and so a method of differential piece-work pay was introduced. As soon as a man's output reached 60 per cent. of the standard he began to receive a bonus. By this system one man increased his earnings 200 per cent. over the sum received before the new methods were introduced. In addition to the great increase of output, the system was found to be less tiring. An employee described it as "best for yourself as well as best for the boss."

CORRESPONDENCE.

SOIL DEFICIENCIES IN INDIA, WITH SPECIAL REFERENCE TO INDIGO.

Our attention has been called to a paper, on the phosphatic depletion of the soils of Bihar, by Professor H. E. Armstrong, in the issue of the *Journal of the Royal Society of Arts* of May 30th last. In this contribution has been included, without our knowledge and consent, two of the interim summaries of the results of our work on indigo, which have to be furnished, under the orders of Government, to certain officials in India. These papers were not intended for publication, as they merely sum up the results obtained from time to time, and do not attempt to give the experimental evidence on which the conclusions are based. As a very incomplete account of our recent work on indigo has in this manner been printed, we should like briefly to state the main results we have obtained on the causes of deterioration of Java indigo in Bihar, and to indicate the reasons why we consider the trouble cannot be explained by any theory of phosphate depletion. A paper is being prepared for publication, giving the results in detail.

Our results indicate that the fundamental cause of the deterioration of the Java plant is a botanical one, and that the trouble has arisen from unrestricted cross-fertilisation. Java indigo only sets seed if visited by bees, and is partially self-sterile. The present crop consists of a freely intercrossing mixture of a great number of types, which differ in habit, vigour, time of flowering, extent of leaf surface, as well as in the distribution and character of the root system. Every gradation between annual and perennial types occurs. The first introductions, which did so well in Bihar, consisted of carefully selected seed from the European estates in Java, of a perennial type suitable for growth on heavy soils. Soon after its early

cultivation in Bihar, indigo was almost entirely given up by the Dutch planters and the supply of selected seed ceased. In its place very inferior unselected seed, grown by the natives in Java, was imported into Bihar in large quantities. An examination of the individuals raised from this unselected seed shows that extensive crossing with annual types has occurred. No attempts were made in Bihar to maintain, by continuous selection, the type originally introduced from the Dutch estates. Further, the Bihar methods of seed-growing in vogue at the time automatically eliminated the best types of plant. All these causes led to an alteration in the botanical composition of the crop. The plant then began to suffer from waterlogging during the second half of the rainy season, and the trouble known as wilt made its appearance. This is characterised by a gradual destruction of the fine roots and nodules and a corresponding reduction of leaf surface, followed by the slow death of the plant The problem is to recover by selection those types which will thrive best under Bihar conditions. In this task we are rapidly succeeding.

That the causes of degeneration of Java indigo in Bihar are to be found in the plant rather than in the depletion of the soil in available phosphate will, we consider, be further evident from the following facts:—

1. There is nothing in the general rural economy of Tirhoot to suggest soil deficiency. The population is over 1,000 to the square mile, there is an enormous export of tobacco, oil seeds, and food grains, and the locality produces a large portion of the labour and cattle required in Calcutta and in the jute districts. The local railways pay high dividends, and can hardly cope with the traffic. Practically no artificial manures are imported into this area.

2. When grown in air-tight lysimeters (provided with drainage openings below which can be closed at will) Java indigo escapes wilt during the rainy season if free drainage is provided. When the openings are closed and waterlogging from below takes place, growth stops and wilt appears. There is better growth and less wilt if Pusa soil (said to be low in available phosphate) is used, than if alluvial soil from Kalianpur (exceedingly rich in available phosphate) is employed.

3. The various types of plant differ very considerably in their tolerance of a water-logged condition of the soil and in their general power of repair. All stages between wilted and healthy plants occur together in the same plot. The power of repair depends on the character of the root system and whether the type is annual or perennial. In our selection work we are utilising this power of repair, and are eliminating all individuals which do not possess it to a high degree.

4. Cutting back or heavy pruning destroys to a very large extent the fine roots and nodules. In the early stages of growth wilt is produced by this means much more easily than at a later period. According to the phosphate depletion theory the opposite would be expected.

5. If a branch is left when the plant is cut back in June and July, the foliage becomes wilted, after which new healthy growth is formed at the ground level. Thus healthy and diseased branches can occur on the same plant.

6. If indigo seed is sown in August in a field in which all the plants are dying of wilt, the new crop is perfectly healthy and will set abundant seed. Thus healthy and diseased plants occur side by side and the trouble is not communicated to the new crop.

7. Recovery from wilt is not uncommon. This occurs without the aid of any artificial manure.

8. The substitution of Pusa soil by one third of its volume of an inert aerating material like potsherds or broken bricks increases the growth of indigo by 50 per cent. and the seed formation by 300 per cent. Here a reduction in the amount of phosphate present increases the yield considerably.

9. One of the plots at Pusa has been continuously manured with superphosphate for at least ten years. Pigeon pea (*Cajanus indicus*), a deep-rooted leguminous plant not unlike indigo, cannot now be raised on this land, and is every year practically destroyed by the wilt disease of this crop.

10. All the direct experiments with phosphates only on the indigo crop we have seen or heard of in Bihar have failed. This want of success of the phosphate manuring of indigo has naturally had its effect on the planters, and has led to the local rejection of the depletion theory on which it is based.

11. The work of Dr. Harrison and Mr. Sen, an account of which is to be found in the Pusa publications, shows that Dyer's citric method cannot be applied to the Tirhoot soils, which contain a very high percentage of calcareous matter in a fine state of division. The figures so obtained have been found to have no bearing on the amount of available phosphate present.

12. Provided the content of organic matter is kept up and attention is paid to surface drainage, heavy crops of indigo seed can be raised continually on the same land without any addition of superphosphate. The fifth of such crops in the Botanical Area at Pusa last year in an unfavourable season attracted universal attention. The seed crop on the Pusa farm manured with superphosphate failed.

13. It is only when superphosphate and organic matter are applied together that indigo and other crops in Bihar benefit. As Dr. Voelcker pointed out in the discussion which followed Professor Armstrong's paper, this improvement is no evidence in favour of phosphate depletion. It may be due to several causes. We have found that although Java indigo is a leguminous crop, applications of all kinds of organic matter markedly improve the ordinary as well as the seed crop. Superphosphate when applied with green manure in Bihar produces

its greatest effect on soils the surface drainage of which is poor and whose texture has been affected by heavy rain. There is reason to believe that the result has nothing to do with the addition of phosphate at all, but is due to an alteration in the physical texture of the soil brought about by some constituent of this manure. As is well known, superphosphate is not a pure substance.

Pusa, August 25th, 1919.

A. HOWARD.
G. L. C. HOWARD.

I am glad that Mr. and Mrs. Howard are taking up my challenge, and will publish their results in detail—I trust at an early date, as the recovery of the industry is being delayed by their discouragement of phosphatic manuring. The details must be complete if the discussion is to be fruitful. It would be wasting time and space to join issue upon their unsupported statements.

HENRY E. ARMSTRONG.

NOTES ON BOOKS.

FORESTS OF BRITISH COLUMBIA.—By H. M. Whitford, Ph.D., and Roland D. Craig, F.E., under the direction of Clyde Leavitt, Chief Forester, Commission of Conservation. Ottawa: Commission of Conservation, Canada.

This substantial volume is the result of three years' work on the part of the authors, and is based, as far as possible, on their personal knowledge of the local conditions in each of the districts described. The ground which they had to cover was vast. The province contains approximately 355,855 square miles. Much of it has not as yet been explored with any degree of thoroughness, and means of transport were often lacking, sometimes not even trails being in existence.

The authors state that about 200,000 square miles of the province are incapable of producing forests of commercial value. Some 145,000 square miles lie above the merchantable timber line, while on 55,000 square miles the soil is either too rocky or wet, or the forests have been so completely destroyed by fire that there is no hope for the natural re-establishment of forest conditions for centuries to come. It sounds almost incredible that over 100,000 square miles of timber have been totally ruined by fire, involving a loss which is computed at 665 billion feet board measure! "When one considers," write the authors, "that the total stand of saw material in the whole Dominion probably does not greatly exceed this amount now, the seriousness of this loss, which can be attributed very largely to public carelessness, becomes apparent."

The report estimates that of the species used in the manufacture of pulp and paper (hemlock, balsam, spruce, and cottonwood) there are 170 billion feet, which is equivalent to 243 million cords.

The primary object of the investigation was to secure an estimate of the available supply of timber in British Columbia, but the volume does a good deal more than that, for it contains valuable discussion of the geographic, physiographic, and climatic relations, and the present systems of administration and forest protection. The text is illustrated with maps and with a large number of admirable photographs, which give a striking impression of the wealth and beauty of British Columbian timber.

GENERAL NOTES.

ELECTRO-CHEMICAL INDUSTRIES AT NIAGARA.—The power at present utilised at the Falls amounts, according to the *Engineer*, to 605,000 h.p., whilst schemes in process of development will absorb a further 420,000 h.p. It is estimated that a total of 2,500,000 h.p., equivalent to more than 16,000,000 tons of coal per annum, may be obtained without impairing the natural beauties of the Falls. The substances produced by the various electro-chemical companies cover a wide range, including abrasives, refractories, fertilisers, metals and alloys, inorganic compounds, and a variety of organic substances, such as chloroform, methyl, alcohol, and formaldehyde.

OIL AND CATTLE FOOD FROM RUBBER SEEDS.—The *Technical Review* states that exhaustive experiments have been made on the utilisation of Para rubber seeds for oil suitable for paints, varnishes, soaps, etc., and that the cake produced from the residue after the oil is extracted compares favourably with linseed and other oilcake as a food for stock. Rubber-seed oil has been sold at 250 dollars a ton at a time when linseed oil cost 300 dollars. In British Malaya alone no less than 633,000 acres were actually producing rubber last year, and the seeds, estimated at 300 lb. to the acre, are at present allowed to fall to the ground and rot.

ASSOCIATION OF SUGAR MANUFACTURERS AND CANE-GROWERS.—In Cuba plans have been formulated for the establishment of an "Association de Hacendados y Colonos," the work of which will be divided into nine departments, viz., agriculture and industry, immigration, transportation, statistics, national and import taxes, arbitration, banking and warehousing, moral and material interests, and legal. Among the objects of the association are the passing of beneficial laws, the lowering of the cost of machinery, implements, and other supplies, freights and taxes, loaning money to manufacturers and cane-growers until their produce is sold, intervening in disputes between growers and manufacturers, fixing the cost of labour, etc. It is emphasised that Cuba, as the greatest sugar-producing country, should have the deciding voice in the control of the world's sugar market.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—October 24, 1919.

No. 3493. OCTOBER 31, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Telegrams: "Vacuum, Trowbridge." *Telephone:* 113 Trowbridge.

BURNETT MOTOR TYRES

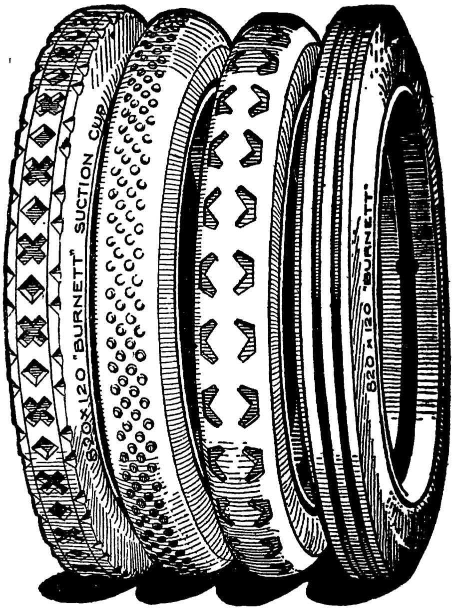
Sole Proprietor:

CUTHBERT BURNETT.

Shetland,
6th May, 1918.

Gentlemen,—
I would thank you to send me your list of tyres, etc. I may say I had one of your tyres some time ago, which gave me every satisfaction.

W. B.



Suction-Cup. Studded. Dauntless. Ribbed.
Patent 14519/10. Reg. No. 642307.

London, N.,
21st June, 1918.

Dear Sirs,—
We return you a tyre, No. 49404, 875 × 105, which may possibly be of interest to you. It has run on the off-side front wheel of a 33-cwt. lorry 7,808 miles without being taken off the rim: it was then punctured; afterwards it ran 1,519 miles, making a total of 9,327 miles. This mileage is considerably more than double the mileage of any other tyre we have had as yet.

POWELL & CO.

COMPLETE PRICE LIST ON APPLICATION TO

The BURNETT Motor Tyre & Rubber Co.

Yerbury Mills, Trowbridge, Wilts.

London Depot - - 71, MORTIMER ST., GREAT PORTLAND ST., W. 1.

CONTRACTORS TO THE BRITISH AND FRENCH WAR OFFICES, Etc.

All communications respecting Advertisements should be addressed to the
ADVERTISEMENT MANAGER, 97, GRESHAM STREET, E.C. 2.

Journal of the Royal Society of Arts.

No. 3,493. VOL. LXVII.

FRIDAY, OCTOBER 31, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

CANTOR LECTURES.

The Cantor Lectures on "Problems of Food and our Economic Policy," by Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., have been reprinted from the *Journal*, and the pamphlet (price 1*s.* 6*d.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2)

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COAL AND ITS CONSERVATION.

By William Arthur Bone, D.Sc., Ph.D., F.R.S.,

Professor of Chemical Technology at the Imperial College of Science and Technology, London.

Lecture III.—Delivered March 24th, 1919.

COAL CONSERVATION AND ELECTRIC POWER SUPPLY.

Introduction.

Having in my previous lecture discussed the question of the carbonisation of coal particularly in relation to public gas supplies, I propose to devote this one to a consideration of the equally important problem of public power supplies.

In the opinion of many competent judges, the question of increasing and reorganising the supplies of power for industrial purposes is one of the most important problems which the country will have to undertake during the coming decade of reconstruction. I use the word "decade" advisedly, because the work of reorganisation will not be accomplished in so short a time as a year or two; but it may be expected that those of us who may be alive in 1930 will then see in operation a comprehensive scheme for public power supply and distribution on co-operative lines, so organised and administered that every power user in the country will have the right to participate, according to the magnitude of his requirements, on the same terms and conditions as all others. If such a scheme can be devised and put in operation, there is no doubt that power production will, on the whole, be much more efficient than it has been in the past, and that important industrial and social consequences will follow.

The Distribution of Power.

Notwithstanding the fact that every factory or workshop in the country requires power in some form or other, and that more than 97 per cent. of such power has been derived, directly or indirectly, from coal, it may seem strange that so little has hitherto been done in the way of generating power co-operatively. There are installed throughout the Kingdom engines of various sorts (but mainly steam engines) of a total nominal capacity of somewhere between 10 and 15 million h.p. The 1907 Census of Production (which are the latest figures available) accounted for 10 million h.p. (exclusive of railway locomotives) in the factories throughout the Kingdom. The distribution of this power was somewhat as follows:—

25	per cent.	at mines and quarries.
20	,,	at iron, steel, engineering and shipbuilding works.
20	,,	in textile and clothing factories.
18	,,	in public utility services.
17	,,	in all other industries.
100		

Again:—

91·2	per cent.	were steam engines (5 per cent. turbine, 86·7 per cent. reciprocating).
6·4	,,	internal-combustion engines.
1·7	,,	water-power machines.
0·7	,,	other kinds of machines.
100		

Of the total capacity of prime movers, 26 per cent. was associated with electrical plants (*i.e.* dynamos generating electricity), and about two-thirds of the latter were engaged in public utility service. The total amount of electricity annually generated in the country in the year 1907 was 2,388 million kilowatts per annum (=273,000 kw. hrs.), of which 1,495 millions, or about 62·5 per cent., were generated in connection with public utility services.

From the foregoing figures it may be concluded (as regards the year in question):—

(*a*) that "public utility plants" were practically all electric plants;

(*b*) that the average load factor on the latter was only about 16 per cent., for

Kw. hrs. generated = 170,000
Capacity of dynamos
in operation = 1,052,783 kw. hrs.

Origin of the present Individualistic Basis of Power Generation.

The individualistic basis upon which practically the whole of the mechanical power was generated in this country during the nineteenth century was the outcome of the natural limitations under which the steam boiler and engine laboured until they could be associated with the dynamo, which was invented and developed much later than the steam engine. The steam generated in a boiler cannot be carried more than a very short distance without total loss of its energy by condensation; so that the engine must be in close proximity to the boiler, and the transmission of power from the engine by shafting imposes a similar limit on the other side. Consequently, not until either the gas engine or the dynamo had been sufficiently developed to make them reliable and efficient commercial machines, was it at all possible to propose any scheme of *co-operative* power production and distribution; and by that time the individualistic basis had become so firmly rooted that men's minds hardly contemplated any other.

Before the advent of the gas engine or the dynamo, all coal consumed for power production in steam plants had to be conveyed to each particular factory using the power. And it was to the demands for cheap and rapid transport of coal which arose between 1750 and 1850 that we owe the inception and development first of all of our canals and afterwards our great railway systems. For (as Jevons remarked) "until coal supplied the purpose, there was not spirit enough in this country to undertake so formidable a work as a canal," and George Stephenson used to say that his locomotive engine was destined to bring forth the strength of Britain lying in her coal and iron beds.

Hence, in those times, the system of power distribution necessarily took the form of conveying the raw coal to each factory, where its potential energy was transformed into mechanical power *viâ* steam boiler and engine; the power was then distributed over the factory through shafting.

With the advent of the internal-combustion engine, however, it became possible to utilise gas from the public mains for power production. And since gas can be distributed over considerable areas at a comparatively small cost, this opened up the first prospect of "collective" power arrangements, at least so far as small power users were concerned. Such a system has certain obvious limitations, and it does not get rid of the necessity of having the power generator (*i.e.* the engine) in close proximity to the place where the power is used.

It was the invention and development of the dynamo and electric motor that finally solved the problem, and made it possible, at the beginning of the twentieth century, to organise big public power schemes on the principle that the power required in a given industrial area shall be generated at the particular place or places (within or without it) where it can be most economically produced. Thus electric power is produced from the falling water at Niagara and distributed through cables to Toronto and other places in Ontario; whilst, in this country, the N.E. Coast Electric Power Scheme affords a good example of how the energy of coal can be similarly distributed from a limited number of large central generating stations.

The Advantage of Co-operative Power Undertakings.

If it be agreed that power may be most efficiently applied to industry by the medium of electricity (I am making this assumption because I have no time to argue it), then undoubtedly there are great advantages to be gained in the way of cheap production by the co-operation of consumers with a properly organised electric power undertaking operating over a large industrial area. And probably no other European country is so well adapted as our own for such co-operative schemes, because of the compactness of our great industrial areas, the densities of their population, and their

proximity to the coal-fields. In every large industrial area there are factories normally working during the day only; others must of necessity work both day and night without ceasing. In some cases, the power requirements are fairly uniform throughout the day's run; while in others the requirements are subject to large and abrupt variations. Everywhere there are enormous energy losses continuously going on which the individual manufacturer is either unable to utilise effectually himself or about which he is indifferent.

Supposing (1) that the manufacturers in such an area, instead of maintaining a large number of independent (and probably inefficient) power stations of comparatively small sizes, were to co-operate in a well-organised electrical power scheme, whereby all the separate factories, with their variable demands, are linked up with a few large and efficient power stations, suitably situated in regard to coal supplies, and equipped with the latest generating machinery in considerable units; and (2) that the power undertaking is prepared not only to sell electrical energy, but also to purchase surplus gas, waste heat, and exhaust steam from any of its customers, and convert the same into electrical energy; it is fairly obvious that, in such circumstances, greater economies could be achieved by reasonable co-operation than would be possible under any purely individualistic scheme.

Importance of increasing the Available Power per Worker Employed in Great Britain.

As was said in my opening remarks, the question of cheap and efficient power supply to our factories and workshops is one of the most important problems of reconstruction. Everyone is agreed that our colossal war debt can only be paid off by vastly increasing the productivity of labour, and it is only by increasing the amount of power used in industry per worker employed that the net output of the individual worker can be increased. By *net* output is here meant the value added by the worker to the material he operates upon (*i.e.* it is the *selling* value at the factory *minus* the cost of the material used).* For it is clear that, except in a country ruled by Mad Hatters, the worker cannot be paid in wages more than a certain proportion of the values he adds to the materials which he handles; and that if he already receives such fair proportion he has no justifiable ground for demanding, nor can he be paid, more unless and until he increases his *net* output. Hence it follows that if the net output and consequently real wages are to be increased, more power per worker must be employed in industry. The cure for low wages is more net output per worker, and this involves more power per individual worker. The economic needs of our day, without which we cannot hope to recover even a measure of our former prosperity are: (1) cheap food, (2) better housing, (3) higher scientific and technical training, (4) more motive power (and relatively cheap coal), (5) a reorganised transport and distribution system; and (6) a sound and equitable system of public taxation, combined with a drastic curtailment of all unproductive public expenditure.

Before the war, each worker in the United States had on the average 56 per cent. more power at his disposal than his *confrère* in Great Britain. Indeed, if industries in which comparatively little power per worker is used be eliminated, it is probable that in those industries where power is mostly used the American worker used twice as much power as his British competitor. Hence his *net* output was much greater, and his real wages were higher than he would have received over here. The American artisan is better educated, and understands that he benefits by increased output, and accordingly he works for it. Unfortunately, the British working man thinks differently: his ideas seem to be (1) that the sum total of material requirements of his market is a fixed quantity, and therefore that no more than a certain quantity of commodities can be absorbed within a given time; (2) that if an individual worker produces, in a given time, more than a certain *net* output he does so to the detriment of his fellows; consequently, (3) that the *net* individual output ought to be limited by rules, and that no worker shall be allowed to exceed such limit. Needless to say, however, the results of such a policy would be ruinous to all concerned, and most of all to the manual workers themselves.

Also, there can be no doubt but that, before the war, power was generated on the average very inefficiently in our mines and factories. It is impossible to give a precise figure for coal consumption per b.h.p. produced, because, unfortunately, the data on which to base such

* According to the last Census of Production the average "net output per worker" in 1907 was only £102 per annum, out of which had to be paid, not only the workers' wages, but also establishment charges and the interest on capital.

an estimate are wanting. But there are grounds for believing that it was probably not much less than 5 lb. per b.h.p. hour. This would mean that on the average we are only utilising about 4 per cent. of the available energy in the coal burnt, the other 96 being wasted. This alone ought to make us profoundly dissatisfied with the present system.

Personally, I have always believed in the principle of co-operative power production in a densely populated industrial country such as ours, and if such principle is accepted there seems to be no other really effective way of putting it into operation except through the medium of electricity.

Seeing, however, that the claims of electricity in this connection are being controverted in certain quarters, I will ask your permission to make a digression at this point in order to explain precisely where I stand in the matter.

Last week Sir Dugald Clerk endeavoured from this platform to delimit the respective fields of gas and electricity in regard to lighting, heating and power. With what he said in regard to both lighting and heating I entirely agree; but I thought he rather obscured the real issue in regard to power, and therefore I think it all the more necessary for me to make it clear.

The partisans of gas are, at the moment, endeavouring to dispute the claims of electricity in regard to power by using an argument which in my opinion is palpably unfair. They point with pride to the marked contrast between the 70 per cent. thermal efficiency achieved in the Metropolitan gas works (*vide* my previous lecture) and the highest efficiency (alleged to be 13 per cent.) achieved by any electric supply undertaking in the Kingdom. But, I venture to ask, is there any connection, or basis of comparison possible, between such figures? The one relates to a ratio between the combined potential energies of the coke, tar, and gas sent out of one kind of factory and that of the coal taken in. The other relates to the ratio of electric energy (power) sent out of another kind of factory to that of the coal used in producing it. There is a great difference between these two ratios, which are not directly comparable because, whilst they postulate one and the same initial substance (coal), they contemplate two entirely different end products. The one starts from coal and ends merely with coke, tar and gas; the other, starting also from coal, ends with electricity. The journey in both cases begins, as it were, at King's Cross; but in the one case it ends at Peterborough, and in the other at Edinburgh. What significance, then, is there in attempting to compare the expenditures of energy in the two cases as though they related to similar distances traversed?

Speaking from a perfectly disinterested and independent standpoint, I deplore the importing of partisanship into the determination of so vital an issue as that of our national power policy. We are not likely to reach a sound conclusion in the matter if it is made the battlefield of the supposed rival interests of gas and electricity, and to be determined by their relative powers of influencing either the Board of Trade or the course of legislation in Parliament. Unfortunately, the gas industry is, in this matter, inordinately jealous of its younger competitor; and instead of frankly recognising the undoubted claims of electricity in regard to power, it is pursuing what seems to me to be an obscurantial policy which, if successful, would defeat the public interest. We shall never attain to a well-balanced policy of "coal conservation" until this narrow partisan spirit and outlook is abandoned and both gas and electricity are regarded as *complementary* instead of *rival* public utilities.

I do not suppose that Sir Dugald Clerk would contend that it is possible to convert coal into electric energy *viâ* coke, tar, and gas with a materially greater thermal efficiency than by its direct combustion in the first instance in the boilers of a turbo-driven electric power station. It seems to me that the real significance in regard to the power question of such figures as those referred to is somewhat as follows—

(*a*) Coal can be carbonised on a large scale in gas works at an expenditure of not more than 30 per cent. of its energy.

(*b*) The resulting coke and gas could then be used for generating electricity with an "over-all" efficiency of (at the most) 22·5 per cent. So that the whole conversion Coal ⟶ Coke and Gas ⟶ Electricity would imply an "over-all" efficiency of $70 \times 0{\cdot}225 = 15{\cdot}75$ per cent. at the most.

(*c*) Alternatively, the coal could be directly converted into electricity at an over-all efficiency of, *at the least*, 17·5 per cent. (I do not accept 13 per cent. as being the best actual achievement in power-station work, for reasons which will be apparent later.)

(*d*) Is it then preferable, for the sake of the by-products obtainable on carbonising the coal

in accordance with (*a*), to adopt the combination (*a*) + (*b*) instead of the direct process (*c*)?

The correct answer to (*d*) at the *present* moment, and in the light of *present* circumstances, would, I believe, be in the negative, because (as will be explained later) electricity can be generated with a 17·5 per cent. thermal efficiency from low-grade coals which it would never pay to carbonise at all in gas-works. Indeed, I regard the economic functions of the gas-works and the electric power station to be quite distinct, and in no sense really competitive or antagonistic. The function of the gas-works is to convert high-grade coals into gas, coke, tar, ammonia and other valuable products, whereas that of the power station is to convert low-grade coals into electric energy.

I am convinced (*a*) that the cheapest and best means of supplying the public with *heat energy* is to distribute it in the form of *gas*, and (*b*) that, if public *power* supplies are required the energy will be best distributed as *electricity* and not as gas. Whether, in transforming coal into electricity, a gas engine or a steam turbine ought to be employed as the prime mover is entirely a subsidiary matter. The real question is, will the electric motor be the pivot of our future industrial power system or not? Personally, I think it will. If so, then our chief concern at the moment must be to ensure that the nation adopts a sound policy in regard to the coming reorganisation of its electric power system.

Reasons for establishing a Co-operative Electric Power System.

The advantages of some co-operative electric power systems are at once apparent when it is considered:—

(*a*) That the production of power is becoming more and more a specialised process;

(*b*) That the most economical generation of power is only possible with larger units, and with a better and more constant load factor than most individual establishments can employ. Also, the capital expenditure for the total h.p. required in the country would be greatly reduced;

(*c*) That in large power stations, equipped with the largest and most modern units, and superintended by specially trained fuel and power engineers, it is possible to burn under the boilers, with good average results, *inferior* grades of coal which could not otherwise be utilised at all. Also, that the recovery of by-products would be more feasible in connection with such stations than with small private plants;

(*d*) That co-operative production means that the small manufacturers and rural industries generally will have cheaper power at command. Also, that an electric motor would soon become an indispensable part of the equipment of every house—a great boon to overworked housewives.

Inefficiency of the Present System of Electric Power Supply.

The present system of electrical power distribution throughout the country, which is undertaken by over 600 authorities in as many separate districts, is technically wrong and commercially uneconomical. It is as though our railway system were composed of innumerable small undertakings (municipally or privately owned) with half a dozen different gauges indiscriminately laid out, so that it was impossible to run a through service of goods or passenger trains between, say, London and Manchester, or Bristol and Newcastle. Also, the average size of the existing generating stations (5,000 h.p.) is only about one-fourth what should be the smallest machine in a modern public station.

Hitherto, local jealousies, as well as vested interests, which our lawyer-ridden Parliament has fostered far too much, have blocked, and are still blocking the way. How often in the past, in connection with water, gas, and electric light schemes, has Parliament encouraged the formation of small rather than of large and more efficient undertakings—a policy which has proved as disadvantageous to the community at large as it has been profitable to the lawyers who frequent the Parliamentary Bar.

A typical example of this sort is afforded by the public electricity supply for Greater London (area, 693 square miles; population, 7¼ millions), in which there are, or were recently, no less than 65 separate authorities supplying electricity, upon 49 different systems, from 70 generating stations containing 585 engines, and distributed at 24 different voltages to the consumer, who is charged at one or other of over 70 different rates and prices! Thus, as a resident within the area, I am being charged the truly astonishing price of 7½*d*. per unit for current at my house,* and Londoners as a whole pay very dearly for a most inefficient electric

* Since the lecture was delivered, I have received notice implying that this may be increased to 10*d*. per unit, a perfectly preposterous figure.

supply, which ought to be thoroughly overhauled and reorganised.

The average size of the generating stations is only 5,285 k.w., and of the generating units only 632 k.w. Many of the older stations contain reciprocating engines, and some have even to cart their coal—a truly ridiculous state of affairs. But, notwithstanding these disadvantages, London's demand for current per head of the population has increased five-fold since 1900, and is still expanding. There is probably no other area in the world which, in regard to density of population, easy access by sea to abundant fuel, and possibilities in the way of rapidly expanding demands for electricity both for power and lighting, is more admirably adapted for the development of a public supply of cheap electricity under a single authority, with consequent great economy of fuel and in the cost of production generally. How long will the people of London allow these natural advantages to be nullified by the short-sighted policy which has prevailed hitherto?

With regard to the country as a whole, there can be no doubt but that, even in the best managed power plants, whether company or municipally owned, coal is being needlessly wasted, chiefly on account of (*a*) the small size of generating stations and units; (*b*) unsatisfactory load factor, and (*c*) bad location of many of the plants in regard to condensation facilities. Thus the average coal consumption of some of the principal Lancashire and Cheshire electric supply systems has been given as 3·275 lb. per k.w. generated; whilst a few weeks ago, Mr. W. Wilson, Technical Adviser to the Coal Controller, stated at a meeting of the Junior Institution of Engineers, that during the year ending March 31st, 1918, 421 electric supply undertakings in the Kingdom generated 4,674 million k.w. units with an average consumption of 3·47 lb. of coal per k.w. But, under the best conditions now possible, it need not to have exceeded 2·0 lb. per k.w., and probably in the near future it will be possible to do it for not more than 1·75 lb.

The Coal Conservation Committee's Proposals.

The Coal Conservation Committee (Power Section), having considered the whole question from a technical standpoint, made certain recommendations concerning the post-war organisation of public power supplies which, having been substantially endorsed by the Board of Trade Electric Supply Committee, will probably form the basis of legislative proposals in the near future.

It is proposed:—

(*a*) To divide the country into a limited number of areas (16 are suggested), throughout each of which there shall be a standard periodicity and trunk main voltage;

(*b*) That the generating plants and units within each area shall be of the largest size required to ensure the maximum fuel economy and general efficiency in working. Units of not less than 20,000 h.p. ought to be used, and in the largest stations 50,000 h.p.;

(*c*) That such plants shall be put down in the most favourable place or places for economical generation (*e.g.* at the pithead if a very inferior coal has to be used, or near a river or estuary where condensation facilities are best);

(*d*) That the main trunk system shall collect any waste power (surplus gas or waste heat) available, which (after conversion into electric current) shall be distributed to where it can be most profitably used.

Choice of Prime Movers, Gas or Steam Engines for Power Station Work.

We shall not be far wrong in assuming for our present purposes that the heat equivalent of the available energy in 1 lb. of a good average coal is 13,000 B.Th.U.s. Inasmuch as the heat equivalent of a horse-power is 2,564 B.Th.U.s, it follows that, were we able by any means to transform the available energy in coal into mechanical power without loss of any kind, we should obtain a horse-power-hour output of work by the expenditure of about 0·2 (one-fifth) lb. of coal.

There are two principal ways in which we may convert the energy of coal into mechanical work. One is by raising steam in a boiler and then utilising as much as possible of the energy of the steam in some form of steam engine, either of the reciprocating or turbine type; the other is by gasifying the coal completely in some form of gas-producer, where the incandescent fuel is converted into a mixture of CO_2, CO, H_2, CH_4, and N_2, under the action of a steam and air blast, and then burning the resulting gas in an internal-combustion engine. Both these methods are imperfect, of course; but it may, perhaps, be of interest if we compare them from the point of view of thermal efficiency.

In the first place, the thermal efficiency of a

good modern type of coal-fired boiler is not far short of that of the gasification of coal in a gas producer, when allowance is made for the fact that it is necessary to clean and cool the resultant gas before it is delivered to the engine. We shall not be far wrong in putting down the efficiency of each method under good working conditions at about 75 per cent. Now, under favourable working conditions, a gas engine will convert about 27 per cent. of the energy of the gas supplied into available horse-power, so that the coal consumption required to obtain a shaft-horse-power-hour by means of the combination of an efficient gas producer and a gas engine need not be more than 1 lb.—

$$\frac{0 \cdot 20}{0 \cdot 75 \times 0 \cdot 27} = 1 \text{ lb. per b.h.p. hour.}$$

Fifteen years ago the efficiency of the best type of reciprocating engine was not more than about 13·5 per cent.; so that the combination of the best steam boiler and engine of that day did not convert more than, perhaps, 10 per cent. of the available energy of the coal into shaft horse-power. Hence the coal consumption of such a system would be—

$$\frac{0 \cdot 20}{0 \cdot 75 \times 0 \cdot 135} = 2 \cdot 0 \text{ lb. per b.h.p hour.}$$

During recent years such great advances have been made in the development of the steam turbine that it has for the time being entirely out-distanced the gas engine as a "power-station" machine, except for comparatively small units of, say, less than 3,000 b.h.p. capacity. According to the published results of trials on the new 35,000 h.p. Parson's turbo-alternator, erected at the Fisk Street Power Station in Chicago, the fuel consumption on so large a turbine steam set (assuming a boiler efficiency of 75 per cent.) has now been reduced to 1 lb. of coal per shaft-horse-power-hour; so that there is now probably little to choose between the thermal efficiencies of the best types of steam and gas systems, each working under the most favourable conditions. But from the point of view of the size of units, the turbine has shot far ahead of its rival (the large Parson's turbo-alternator recently installed at Chicago is 35,000 h.p. capacity, far surpassing anything yet attempted with an internal-combustion engine unit). And whereas a gas engine only works at its highest efficiency with a high load factor, a turbine maintains its efficiency over a wider range of load than its rival, and at low load far surpasses it. A gas engine requires much more lubrication, but, on the other hand, usually less cooling water than the turbine; and, owing to its simpler construction, the turbine requires less adjustment and repairs, and is more reliable than its rival.

These considerations have led to the almost universal adoption of the steam turbine for large power stations, except in cases where there are available supplies of surplus gases from coke-ovens, blast-furnaces, or the like. On the other hand, for comparatively small units—say up to 3,000 h.p.—where the load factor is uniformly high and not subject to abrupt variations, the gas engine has certain advantages. In any case, however, the choice between the two rival systems will not usually be determined on purely thermal considerations, but on the other equally important factors.

The Economy of Large Generating Stations.

The economy of large generating stations may be ascribed to the following factors, namely:—

(*a*) Better condensation facilities;

(*b*) The employment of much larger generating machines with higher boiler pressures (450 lb.), and complicated but more efficient steam cycles. High boiler pressures, with large turbo-alternators, give greater thermal efficiencies than are possible on any combination in smaller sets; for very high steam pressures are not economical with small turbines, because of the larger proportionate clearances;

(*c*) The use of very large machines, employing complex steam cycles, is not justifiable unless the "load factor" is good (which should be at least 50 per cent. or more), and a good "load factor" is hardly possible except in case of large public stations generating current for the requirements of a wide area.

As an example of the fuel economy now attainable in large stations, I am permitted to say that in one of the largest public power stations in Great Britain the actual development of heat by the combustion of a very inferior grade of coal in the boilers per k.w. sent out of the station does not exceed 19,500 B.Th.U.s, under ordinary daily working conditions, which corresponds to a thermal efficiency of 17·5 per cent.; also, that in a large *super-station* now in course of erection in the country, and which will probably be in operation by the end of the present year, the plant has been so designed that it is confidently anticipated that no more than 16,000 B.Th.U.s will be expended per k.w. sent out. The efficiency

will therefore be quite 20 per cent. on the current sent out.

CONCLUSION.

If, then, it be conceded that, from a national standpoint co-operative power production in large central stations is the right policy for this country, it seems to me difficult to resist the conclusions (1) That the power ought to be generated preferably from *low-grade* coals, burnt under expert supervision in large boilers with high pressures and "super-heat"; (2) That the "super-heated" high-pressure steam should be utilised for generating electricity in large turbo-alternators, with good condensation facilities; and (3) That the electricity so generated should be distributed as high-tension current through public mains over a radius up to (say) twenty miles from the generating station.

I cannot see, nor has it yet been demonstrated, that public gas distribution offers any practicable alternative solution of the power problem, and I regard the present opposition of the gas interests to the idea of electric power distribution as purely obstructive and reactionary.

[The lecture concluded with an exhibition of lantern-slides and data relative to (*a*) the North-East Coast Electric Power Scheme, as a typical example of what may be accomplished in the way of co-operative power generation, and (*b*) the applications of electric power in driving rolling-mills in steel-works.]

CHINESE VEGETABLE PRODUCTS OF INTEREST.

An instructive and valuable series of reports on Chinese products of commercial interest has been written by the United States Commercial Attaché at Peking, Mr. Julean Arnold. From Mr. Arnold's discussion on Chinese vegetable products the following particulars of some of the lesser known products are extracted.

Aniseed.—Aniseed or star anise is used in the manufacture of absinthe, anisette, cordials and medicine. It is made from the fruit of a small evergreen tree, which grows wild in Kwangsi Province in South China. China exported in 1917 about 1,500 tons of seed and about 800 tons of oil.

Apricot Kernels.—An edible variety of apricot produced in North China, is often mistaken for almonds, and serves as a splendid substitute for almonds for confections, being cheaper and similarly flavoured. Upwards of 4,000 tons of apricot kernels are exported annually from North China, 80 per cent. through the port of Tientsin. Three-fourths of these are the sweet and about one-fourth the bitter variety, the latter selling for about one-fourth the price of the former.

Bamboo.—The number of different varieties of bamboo found in China is over thirty. Mr. F. N. Meyer, Agricultural Explorer for the United States in China, made an extended study of the bamboo for the purpose of demonstrating its utility for introduction into the United States, and the results of his studies are available at the Department of Agriculture. Some varieties grow 35 ft. in a month. A book could be written describing the manifold uses of bamboo in China. For building purposes, rafts, matting, window shades, door screens, piping, carrying poles, scaffolding, fencing, boat poles, ribs of sails, brooms, crates, cages, chop sticks, Chinese writing-brush handles, fan and umbrella frames and handles, containers, furniture, carvings, irrigation wheels, baskets, smoking pipes, combs, hairpins, pillow and mattress fillings, hats, thatching, etc., it is used extensively throughout China. It is largely employed in certain medicines. Bamboo pulp forms the chief product used in the manufacture of paper in China. Bamboo shoots are an extensive article of diet in China, and would easily find favour elsewhere for salads and as a vegetable.

Barley is grown quite extensively in North China, and particularly in Manchuria. A huskless barley is produced in Kansu.

Beans.—The sudden rise of the soya bean from a position of comparative obscurity to a position of prominence in the commercial world, during a period of little more than a decade, constitutes one of the commercial wonders of the world.

In the Far East soya beans are used for the following purposes: (1) For bean sauce or soy ("soya" is a corruption of the Japanese "shoyu"), known to the Chinese as "chiang-yu," and made by boiling the beans, adding an equal quantity of wheat or barley and leaving the mass to ferment; a layer of salt and three times as much water as beans are afterwards put in when the liquor is pressed and strained. The sauce is clear, resembling Worcestershire sauce, and is used in a somewhat similar way. (2) For "chiang," or bean paste, eaten with fish, meat and vegetables, and made by boiling together one part yellow beans and two parts water, grinding the mass into the shape of a pancake, and laying it in a cool place for fermentation; it is completed in two months, after which salt is added from time to time as the water evaporates. (3) For "tou-fu," or bean curd, made from green or yellow beans, by steeping the beans in water, grinding in a stone mill, passing through a strainer (which retains the epidermis of the beans), then boiling in a pot, after which the preparation is poured off into a jar, and well-diluted brine added, which, being stirred in, causes coagulation of the proteid compound legumin or vegetable casein; the mixture is then ready to be drained off and cut into blocks for sale. (4) For a form of flour extensively used for bean vermicelli, which is tasty and nutritious. (5) As a table vegetable. (6) For soups. (7) For making confectionery (in Japan). (8) For oil, as a substitute

for lard, as a lubricant, as an illuminant, and to waterproof cloth, paper umbrellas, and lanterns.

Bean Products.—Bean cake is the residue after the oil has been extracted, and is extensively used throughout the Far East as a fertiliser and as cattle feed. Bean milk is produced from the small yellow soya bean. The product looks like un-skimmed cow's milk, has a slight odour of beans, a fat content of 3·1, is not unpleasant to the taste, and can be delivered to customers at Changsha at two shillings per month for one pint a day.

In the west, the soya bean is little used as a foodstuff. Its principal use is for oil; a refined variety mixed with other oils serves as a salad oil or in margarine. One of the chief uses to which bean oil is put in western countries is in soap manufacture, though it is not so good for this purpose as cotton-seed oil. It is also used in the manufacture of various edible goods, toilet powders, paint oils, lubrication and lighting oils. The soya bean contains about 18 per cent. oil. There are three main classes of soya beans—the yellow, the green, and the black—each with several sub-varieties. Manchuria is the centre of the soya bean and bean-oil industry, with Dairen as the chief port of export. In 1917 Dairen exported 110,000 tons of bean oil, the bulk of which went to America. The greater part of the bean cake goes to Japan.

Camphor.—The camphor of commerce is made from the camphor tree by destructive distillation. The trees, after reaching fifty years of age, are cut down, chipped, the chips boiled in vats, and the distillate collected in crystals upon straw. It is put through a refining process. Camphor is used mainly in the manufacture of celluloid, smokeless powder, fireworks, and medicines. The island of Formosa, where the camphor is held as a Japanese Government monopoly, supplies about 75 per cent. of the world's consumption. Japanese interests tried about twelve years ago to secure a monopoly of the production of camphor in Fukien Province, the main source of China's supply, but failed. As there has been no systematic replanting in China, the number of trees has continually decreased until Fukien's supplies have become nearly exhausted. Kiangsi, Szechwan, and Yunnan Provinces are said to have considerable numbers of trees, especially the inaccessible regions of south-western Yunnan. During 1917 China exported 473,000 lb. of camphor, 90 per cent. of which came from Kiangsi Province.

Cassia Bark and Oil.—Cassia (*Cinnamomum cassia*) is a large and useful tree found on the borders of Kwantung and Kwangsi Provinces, and in South China generally. The bark (*cassia lignea*) is stripped off, allowed to lie for twenty-four hours, during which time it undergoes a species of fermentation, and the epidermis is easily scraped off. It dries into a quilled shape, in which it comes to market. It is smaller quilled, breaks shorter, and is less pungent and acrid than cinnamon.

Cassia oil is obtained from the leaves and the twigs by distillation, and is used in medicine. It is also used in perfumery and flavouring condiments. Cassia buds, refuse and twigs, to the extent of 6,000,000 lb., were exported during 1917.

Castor Oil.—The extensive use of aeroplanes in the war has greatly increased the demand for castor oil, which is used as a lubricant for the motors. It is also used for mixing with paints, for medicinal purposes, for cooking and illuminating purposes, and for mixing the colours for Chinese seals. The oil is extracted from the seeds by simple pressure. The crude oil is boiled with water, which separates the alkaloids and other impurities, the water being then evaporated. In China castor beans are planted on the borders of fields to prevent animals from wandering on to them, as the beans are poisonous because of the alkaloids they contain, and the animals will not devour them. They are found quite abundantly over most of China. The oil has only recently found a place in foreign trade, and there should be good prospects for its development.

Cotton.—Estimates of China's cotton production vary considerably, but in normal years it seems to be between 1,500,000 and 2,000,000 bales of 500 lb. each. The production is increasing rapidly, and is capable of vast development. Scientific methods of planting would increase the yield per acre two or three fold, and the acreage planted could be increased almost without limit. China now produces the cheapest cotton in the world, but taxes it higher in transportation to mills in China than for export abroad. Cotton is grown throughout the Yangtze Valley and in Shantung, Shensi, Shansi, Chihli and some of the southern Provinces. Generally, Chinese cotton is considered a short-staple product. This is especially true of that grown in the north and shipped from Tientsin. The best cotton in China is that grown in the Wei Basin in Shensi from American seed. South Tungchow, near Shanghai, also produces a very high-grade cotton.

Cotton-seed Oil, Cake and Hulls.—Chinese cotton-seed is smaller than the American, so that the yield of oil is proportionately smaller. The Shanghai mills produce about 10,000 tons a year. The crude oil is used for cooking and illuminating purposes by the Chinese. It loses about 14 per cent. in the refining process. The seeds yield about $8\frac{1}{2}$ per cent. crude oil, 36 per cent. cake, 50 per cent. hulls, $\frac{1}{2}$ per cent. lint, and 5 per cent. dirt. The cake finds a ready market for cattle food, and the hulls are in great demand for fertiliser. China exports about 7,000 tons of cotton-seed oil annually, but the home consumption is still greater.

Jujubes, Persimmons and other Fruits.—North and West China produce excellent varieties of jujubes, which when dried are erroneously termed red dates, as well as persimmons, which when dried are erroneously called black dates. These make excellent confections for table use. China exports about 3,000 tons of "black and red dates,"

besides producing large quantities consumed locally. The jujubes are eaten fresh, dried, stewed, or smoked. When dried they somewhat resemble a large dried date. They are boiled in sugared water, then dried. Honey is added for the best grades.

Gall nuts, or oak apples, are produced by insects on certain trees, the *Rhus javanica* and the *Rhus potaninii*, found in mountainous regions of West Hupeh, Hunan, Kweichow, Szechwan, and Kwangsi. The galls are oblong, rough, and tubular, the shell hard, brittle and gummy, and the hollow centre has a cottony ball, the covering of the pupa. They are used to dye silks black, in tanning, and as medicine. They are reputed to furnish the finest tanning extract in the world. China exports gallnuts to the extent of about 15,000 tons a year, 75 per cent. going to the United States, which now controls this trade. Hankow and Chungking are the principal ports of export.

Ginger and Galangal.—Ginger (*Zingiber officinale*) is grown in the West River and hilly districts of north-western Kwantung, throughout Szechwan, and in certain central provinces. It is eaten to a considerable extent in the green state as a condiment and a corrective. The preserved ginger comes mostly from Canton. Galangal (*Alpinia officinarum*) is sometimes mistaken for ginger proper. It belongs to the ginger family. The root is smaller than that of the ginger, being usually about two inches long and half an inch thick. It tastes like a combination of ginger and pepper. It is used as a preserve, like ginger, and also medicinally. It is cultivated in the Island of Hainan, off the Kwangtung coast. China exports about 1,000 tons of galangal and about 5,000 tons of ginger annually.

Ramie.—China produces grass cloth woven from ramie, pineapple, or jute fibres. The best ramie is produced in Kiangsi Province, where a considerable quantity of the cloth is woven. Szechwan Province produces large quantities of ramie, but the cloth is coarser than that produced from the superior Kiangsi fibre. Kwangtung Province also produces some good fibre. It is unfortunate that the Chinese Government has not given this industry greater attention, for it appears to possess notable possibilities.

Kiangsi, as stated above, produces the best ramie (*Boehmeria nivea*) as well as the largest quantity. It is differentiated by the natives from hemp in that it is never irrigated. It is called a dry or mountain hemp, although the districts in which it is produced have a plentiful rainfall; the soil and the character of the land are such that the water does not inundate or stand. The seed must be sown in the autumn, and the crop can then be reaped the following year. The natives contend that the best plants are produced from the planting of the roots. The plant will last for from five to seven years. It grows to a height of 6 or 7 ft. Three cuttings a year can usually be made, although in some places only two are possible. The stalks are stripped of leaves, bundled according to size, and in some regions soaked for a few days in water. After this they are bent, and the fibre is removed by a beating and soaking process, while at the same time the mucilaginous substances in the plant are scraped off with a dull-edged knife. The process requires several days, and is all done by hand. When ready for weaving the fibre is boiled, sometimes in lime water, and beaten so as to remove the resin and gum, and make possible the separation of the fibres. This process has to be repeated a number of times. The whole process of cleaning the fibre and weaving the cloth in China is crude. The industry has not yet been commercialised. Several efforts have been made to introduce modern machinery for decortication and degumming the fibre, but apparently without success. However, with cheap labour, the present crude methods seem to produce a good fibre, and the industry assumes a position of considerable importance to the sections of the Pearl River delta in Kwangtung, Kwangsi, and Hupeh, where most of the Chinese grass is raised. But its future is still uncertain.

The ramie is bought according to quality, crop, and length. The first crop brings better prices than the second or third, and long fibres better prices than short. Because of their strong fibrous nature they are suitable for incandescent gas mantles, etc.; they produce a very fine quality of yarn suitable for light, strong underwear. For export the ramie is hydraulically pressed into bales weighing about 600 lb., measuring between 11 and 12 cubic feet. China exports about 20,000 tons annually.

Kaoliang.—Kaoliang, or sorghum, as it is sometimes known, is one of the staple crops of North China and Manchuria. It is sown after the wheat is harvested, grows to a height of 10 ft., and is ready for cutting in September. An acre will produce from 35 to 45 bushels. It is used for human and animal food, and for making a spirituous liquor very popular with the Chinese. Three varieties are produced—white, red, and glutinous. The white is the best and is cooked like porridge. The red is best suited for wine, while the glutinous is used for dumplings, pastry, etc. The stalks are used for thatching houses, for packing and bridging, as matting for floors, and for fuel. The green blades furnish fodder for cattle.

Lichees.—The lichee is a delicious fruit raised in South China. When dried it is known on the American Pacific Coast as the "China nut." The fresh fruit is canned at Amoy, Foochow, and Canton, and considerable quantities are exported, the greater part probably going to the Chinese populations abroad.

Licorice Root occupies a prominent place in the *materia medica* of China, and in recent years has assumed a position of importance in her export trade, the Customs returns for 1917 showing an exportation of 15,000 tons, mostly from Tientsin.

The licorice comes for the most part from Northern and North-Western China, growing wild in the Kokonor and Inner Mongolia districts. It is used as a sweetener and adulterant in the manufacture of porter, tobacco, and chewing gum, apart from its ordinary medicinal use.

Narcissus Bulbs.—A short distance inland from Amoy there is a bit of marshy ground which produces the bulk of the narcissus bulbs that are so highly prized by Chinese everywhere, and that for many years have been an article of export. Three million bulbs is the usual quantity produced annually for shipment, one-third of these going abroad.

Oranges.—The southern provinces of China produce many varieties of oranges, the most famous of which is the delicious sweet Swatow "honey orange," of which 6,000 tons are exported annually. It is stated that eighty different varieties of oranges are produced in China.

Peanuts.—Just before the outbreak of the war the peanut industry in China had reached its highest point in its relation to the foreign expert trade. The annual exports then were about 70,000 tons of shelled peanuts and about 50,000 tons of oil. More than 40 per cent. of these amounts went from the port of Tsingtao, as Shantung has developed into the largest peanut-producing province in China. Seeds are sown there in May or June and harvested in October or November. The yield runs from two to four tons per acre. The province is estimated to produce more than 200,000 tons of unshelled peanuts a year. Honan and Chihli rank next in importance to Shantung in the production of this product. In 1917 China exported 25,000 tons of shelled peanuts, 7,000 tons in the shell, and 30,000 tons of oil.

Safflower.—Safflower (*Carthamus tinctorius*) is cultivated in Szechwan, where it is used for producing a beautiful red liquid for dyeing silks. It is used also in rouge. It makes a valuable oil, and the powdered cake is a nutritious cattle food. In semi-arid regions it is adapted to dry-farming methods.

Sesame.—The potentialities latent in certain products and industries in China were shown in the development of the soya bean. The extraordinary growth of the export trade in sesame seed is another instance. Up to 1897 sesame seed was scarcely mentioned as an article of export. Prior to the outbreak of the war, the exports one year reached 164,000 tons, valued at 12,000,000 taels. The war, however, has so reduced tonnage and increased freight rates, that this trade (in a bulky product) has suffered severely.

Sesame is produced throughout a very large area of China, but particularly in the lower Yellow River Basin, where light, sandy soil favours its growth. It is often planted with cotton seed, the two growing up together, but the sesame is ready for harvesting before the cotton bolls are matured. The seeds are used as food, but are chiefly valued for their oil. Of the three colours, the white, the yellow, and the black sesame seed, the first-named contains the highest percentage of oil. By their native methods the Chinese get from 40 to 50 per cent. of oil from the seeds. The oil is about four times as valuable as rape-seed oil; hence in China, where no laws prevent adulteration, the sesame-seed oil in the market is likely to be adulterated with rape-seed oil. The seed rather than the oil was exported in large quantities to Europe, where the oil was extracted by improved processes. It is used in the manufacture of margarine, salad oils, and soaps.

Vegetable Tallow is produced from a bean or seed of a tree—the *Sapium sediferum* or tallow tree—which grows wild in hilly sections of South, Central, and West China. The seeds (three and sometimes four to a pod) are about the size of a coffee bean. The trees are prolific bearers. The fruit, when ripe, some time in November, is spread in the sun to dry, when the pod opens and the seeds are exposed. They are covered with a greyish white substance, which is removed by steaming and then rubbing through a bamboo meshed sieve. This substance, the tallow, is melted and formed into a mould. It is reported that the seeds yield 28 per cent. tallow. The seeds, after the removal of the tallow, are pressed for their oil content, which is heavy (about 40 per cent. of the total). The oil is said to possess the property of turning grey hair black. It is used as an illuminant and for mixing with higher quality and higher priced vegetable oils. The refuse is valuable manure for the tobacco plant, and serves as a fertiliser generally.

In 1917, 20,200,000 lb. of vegetable tallow were exported from China, all from Hankow. The best quality, the Kinchow, and the second quality, also white, are used in making high-grade toilet soaps and face creams. The third and fourth qualities, which are of a greenish shade, are used in cheaper soap and candle manufacture.

Varnish.—Varnish is produced in China from a tree commonly spoken of as the varnish tree, but known botanically as *Rhus vernicifera*, which is found in abundance in the mountains of Hupeh, Kweichow, and Szechwan. The varnish is taken from the tree after it is about 6 in. in diameter by tapping at intervals of from five to seven years until the tree is fifty or sixty years of age. A good-sized tree will yield from 5 to 7 lb. of varnish. The natural colour of the crude varnish as applied is black. It is considered the most durable varnish known. One peculiarity is that it hardens only in a moist atmosphere. In China it is erroneously known among the foreign communities as "Ningpo varnish," probably because it first came into contact with foreign trade there. Many persons are poisoned when they come into even atmospheric contact with this varnish, which fact, unfortunately, reduces its trade possibilities enormously. As yet no method has been discovered whereby this poisonous quality can be counteracted.

Hankow is the principal port of export for varnish. China's exports of varnish average about 1,000 tons a year.

Wood oil is the oil taken from the nuts of two varieties of the *Aleurites*. While the trees are different, the oils by chemical analysis are identical. The "T'ung-yu" (*Aleurites fordii*) is essentially a hillside plant thriving in the most rocky situations and on the poorest of soils where there is a minimum of 29 in. of rainfall, although it will withstand drought as well as a few degrees of frost. The tree seldom reaches more than 25 ft. in height, and is highly ornamental in foliage and flower, suggestive of possibilities for shade-tree purposes. The fruit is a green apple-like one, about the size of a small orange, and contains from three to five seeds with about 40 per cent. oil content. The trees are found for the most part in the Yangtse region west of Hankow, a large part of the trade centreing at Wanhsien. Hankow is the port of export, shipping 80 per cent. of the oil. A little goes out through South China *viâ* Hong Kong. In 1917 Hankow shipped 36,000 tons out of a total trade of 47,000 tons, 30,000 tons of which went abroad. Buyers must safeguard themselves from adulterated oil, as it is a common native practice to add the cheaper native bean oil.

The oil has the following uses:—

In China.—(1) As a paint oil for outside purposes, excelling linseed oil in drying qualities. (2) The cruder oil—applied to native boats—paints, varnishes and preserves in one operation. (3) With the mineral substances "t'u tsz" and "t'o-shen" added, it serves as a waterproofing varnish for silks, etc. (4) As an adulterant in lacquer varnish. (5) As an illuminant. (6) When mixed with lime and bamboo shavings, for caulking native boats. (7) The soot of wood oil produces the best quality of Chinese ink. (8) As a dressing for leather and a varnish for furniture, etc.

In America.—Chiefly for the manufacture of varnish, since it possesses the advantage of drying quickly and of making high-class varnish with cheap gums.

DEVELOPMENT OF RUBBER CULTIVATION IN HAINAN.

There has been a considerable development of the production of rubber in Hainan, an island belonging to China lying between latitude 18° and 20° N. The cultivation is chiefly undertaken by returned emigrants from the Malay States, and it bids fair, writes the United States Consul-General at Hong Kong, to develop into an important industry. Since 1910 the Kiung An Co. has planted 6,000 rubber trees in the Kachek district, and the Ch'iao Hsing Co. 45,000 trees in the Nodoa district. In 1916 rubber was tapped by the Kiung An Co. from 2,000 trees, while in 1917, 3,000 were tapped, these producing 11 catties (catty = 1⅓ lb.) per day; 23 piculs (3,067 lb.) were exported to Singapore, either direct or through Hong Kong and Bangkok, during 1917. Export is made in sheets measuring on an average 16 in. in length, 10 in. in width, and ¼ in. in thickness. Prices obtained from the last shipment realised only £10 per picul, whereas the first consignment sent to Singapore fetched £20 per picul, and was reported to be of first quality.

About the middle of 1917 Lin-I-Shun, a Cantonese merchant in Singapore, obtained from the Ministry of Agriculture and Commerce a grant of 500,000 mow (mow = 0·2 acre) of land on which to grow 5,000,000 rubber trees. When they are in a flourishing condition he guarantees to pay a royalty of 5,000,000 dollars (£1,000,000) to the Government. The Ch'iao Hsing Co. has not yet commenced tapping its trees.

Heretofore the island has been chiefly devoted to the production of live stock (especially swine and small native beef cattle), and sugar, rice, ginger, and other agricultural products. The area said to be suitable for rubber-growing includes a very large part of the entire island.

LAND MINES IN THE WAR.

The *Engineering Supplement* of the *Times* epitomises an account given by Mr. G. F. F. Eagar before the Institution of Mining Engineers of the methods adopted for training officers and men of tunnelling companies for mines rescue work on active service in France. At the end of 1914 it was considered a waste of time to undertake any mining operations that would require more than two or three weeks to complete, but by the summer of 1915 it was realised that the breaking of the enemy's front was a matter of years, not of months. Early in 1915 the activities of the enemy in mining under our positions caused a much broader view to be taken of tunnelling operations in general. Previously practically the only mining undertaken by our enemies had consisted of shallow galleries at points where the lines were very near together.

The mining operations which contributed so enormously to the success of the battle of Messines kept eight tunnelling companies in full work for at least fifteen months. The biggest crater made under or behind the enemy lines during the war was blown at Messines on June 7th, 1917; the distance from the shaft to the centre of this crater was 1,710 ft., while the depth of the shaft and of the gallery below ground was 88 ft. Another of the mines blown on the same day at St. Eloi was laid at a depth of 125 ft., and was charged with 95,600 lb. of ammonal. Such large operations involved increasing risks, often almost as great for the attackers as for the attacked. The deadly nature of the gases given off by the use of large quantities of explosives was early realised, and a call for portable breathing apparatus and men trained in its use met with an instantaneous response. There were thirty-two tunnelling companies engaged on the Western Front, twenty-five being recruited in Great Britain and the remainder in Canada, Australia, and New Zealand. The companies varied in strength from 16 to 20 officers and from 400 to 1,200 other ranks.

NOTES ON BOOKS.

Shore Processes and Shoreline Development. By D. W. Johnson. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.

This book deals with the problems which concern the study of coastal change, and its scope is in the main an investigation of those problems from the mechanical side. The preliminary chapters afford a terse compendium of already published data, and the author's command of the bibliography of his subject is exhaustive. The text bristles with references to the works of standard authors.

Chapter I. is a summation of our present day knowledge of wave action; Chapter II. is devoted to the principles underlying the work of waves and the measurement of wave energy; Chapter III. deals with current action, and Chapter IV. more especially defines the classification of typical foreshores, their emergence and submergence. The first four chapters thus form a condensed statement of the phenomena of foreshore transformation.

The remaining chapters of the book are a careful and scholarly elaboration of the laws governing the development of a shoreline; that is, as already stated, of the mechanical side of such development. Their scope is abstract. The control or regulation of shore conditions by means of vegetation forms no part of the author's field of observation.

The work is admirably produced, and its plates are of high merit. As a record of the age-long forces by which coastlines are being moulded and have been sculptured in the geological past it should become a standard text-book.

A. E. Carey.

GENERAL NOTES.

Japan and Australian Markets.—H.M. Senior Trade Commissioner in Australia reports that Japan has rendered useful service during the war period by supplying the Commonwealth with articles difficult or impossible to obtain elsewhere; but in a great many instances the goods were of most inferior quality and frequently not up to sample, whilst the methods of trading adopted were often unsatisfactory. Complaint is also made of the copying of British and other trade marks and brands. "This has been done in such an open manner that one is led to the conclusion that those guilty of such practices must often be unaware of the significance of their actions." It is considered that on the resumption of normal conditions Japan will lose the bulk of this trade; but with the experience she has gained, combined with her cheap labour, it is possible that she may secure an appreciable share in the supply of cheap goods of the kind formerly obtained from Germany.

Exhibition at Caracas.—A national exhibition will be opened at Caracas on December 19th. An opportunity is presented for the exhibition of British sanitary equipment, which, it is pointed out, is of special importance in view of the fact that the Venezuelan Government has under consideration a scheme for the installation of a proper drainage and sanitary system for the city of Caracas. H.M. Minister at Caracas states that there is a large demand in Venezuela for glass, earthenware, jugs, basins, etc., and also for cheaper kinds. It is suggested that manufacturers of this class of article might like to exhibit. The present rate of exchange between this country and Venezuela is an inducement to Venezuelan buyers to purchase in this country. The *Board of Trade Journal* announces that British firms desirous of participating are invited to consign exhibits to Victor Maldonado, Caracas, who is willing to undertake all responsibility free of charge.

Indian Tobacco Industry.—The *Indian Trade Journal* calls attention to the encouraging prospects of the above industry as a result of the one-sixth preference accorded by the United Kingdom. The bulk of the tobacco grown in India is consumed locally; but there is a large and increasing export trade. The chief pre-war destinations of the leaf were (1) Aden and Dependencies; (2) Hong Kong; (3) France; (4) Straits Settlements; (5) Holland, and (6) Germany. For cigars the Straits Settlements are India's principal customers. The effect of the war was to divert a portion of the exports to the Persian Gulf. The Persian Gulf also absorbed in 1918–19 the bulk of the cigarettes exported—138,390 lb. out of 169,817 lb. In recent years there has been a conspicuous increase in the number of cigarette factories in the country. Repeated efforts have been made in India for many years to improve the quality of the produce; these efforts have met with some success, and the quality has improved. Throughout British India in 1917–18 there were 1,014,862 acres under tobacco, and in the Native States about 100,000 acres.

Japanese Shipbuilding Profits.—The profits of the principal Japanese shipbuilding companies during the first half of 1919 are stated by the American Consul in Yokohama to be as follows: Yokohama Dockyard, 590,885 yen; Osaka Ironworks, 7,060,000 yen; Ishi-Kawajima shipbuilding, 1,093,414 yen. The companies have fairly large contracts with the Japanese Navy, and it is said that the Nippon Yussu Kaisha require 100,000 more tons before the end of next year. Both this company and the Osaka Shosen Kaisha are opening up communications with Germany.

Department of Scientific and Industrial Research.—Sir Henry Alexander Miers, D.Sc., F.R.S., Vice-Chancellor of the University of Manchester, and formerly a member of the Council of the Royal Society of Arts, has been appointed a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

WATER-POWERS OF FINLAND.—The total water-power of Finland at average water-level is estimated in the *Bulletin* of the Federation of British Industries at 3,000 h.p., of which about 1,050,000 h.p. could be of direct use industrially. At present only about 150,000 h.p. is utilised. Of seventy-nine waterfalls with potential capacities of horse-powers from 5,000 to 300,000, forty-two are between 5,000 and 20,000, twenty-five between 20,000 and 50,000, six from 50,000 to 100,000, and six from 100,000 to 300,000.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 3...University of London, University College, Gower-street, W.C., 5.30 p.m. Mr. W. R. B. Prideaux, "Indexing of Books and Periodicals: Indexing in Business and Daily Life."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. W. Brown, "Sewer Ventilation and Health."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. C. A. Mitchell, "Black Lead Pencils and their Pigments in writing." 2. Captain E. T. Sterne, "Shawiningan Chemical Industries."

Geographical Society, 135, New Bond-street, W., 8.30 p.m. Major K. Mason, "Central Kurdistan."

Brewing, Institute of, Imperial Hotel, Russell-square, W.C., 8 p.m. Discussion on (1) Hops, (2) Casks, (3) Materials.

TUESDAY, NOVEMBER 4...University of London, University College, Gower-street, W.C., 5.30 p.m. Mr. J. H. Helweg, "Holberg and Ewald." (Lecture I.)

Industrial League, Council Chamber, Guildhall, E.C., 4.30 p.m. Dr. R. Wells, "Higher Commercial Education and the Universities."

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Presidential Address by Sir J. P. Griffith.

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. Mr. E. H. Allen, "Exhibition of Skiagraphs of *Vermiculina* from examples grown in a hypertonic tank." 2. Dr. G. Marshall, "On the Species of *Balaninus* occurring in Borneo (Coleoptera, Curculionidæ)." 3. Miss J. B. Proctor, "On the Variation in the Number of Dorsal Scale-rows in our British Snakes." 4. Mr. G. A. Boulenger, "On some new Fishes from near the West Coast of Lake Tanganyika." 5. Hon. P. Methuen, "Description of a new Snake from the Transvaal, together with a new Diagnosis and Key of the Genus *Xenocalmus*, and of some Batrachia from Madagascar."

WEDNESDAY, NOVEMBER 5...Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. L. Aitchison, Valve Failures and Valve Steels in Internal-combustion Engines."

University of London, University College, Gower-street, W.C., 3 p.m. Dr. E. G. Gardner, "History and Drama in the Divina Commedia." (Lecture III.)

5.30 p.m. Mr. H. E. Palmer, "Methods of Learning Foreign Languages." (Lecture I.) Mr. I. C. Grondahl, "Holberg and Wessel." (Lecture I.)

6.15 p.m. Dr. J. C. Stamp, "Fundamental Principles of Taxation in the light of modern Developments." (Lecture I.)

7 p.m. Mr. J. J. Guest, "Guest's Law and Design, (Civil and Mechanical Engineering)." (Lecture I.)

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. G. R. Thompson, "Egyptian Bricks." 2. Messrs. A. R. Powell and W. R. Schoeller, "The Analysis of Brazilian Zirconium Ore." 3. Miss E. M. Taylor, "The Halogen Absorption of Turpentine."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Professor M. A. Gerothwohl, "Main Currents in Roumanian Literature."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. P. J. Johnston, "The Timber Domestic Architecture of Kent, Surrey, and Sussex."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Dr. W. G. Savage, "Housing Problems in Rural Districts."

Oriental Studies, School of, Finsbury-circus, E.C., 5 p.m. Dr. A. S. Yahuda, "Mediæval Spain: Moorish Monuments."

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. T. J. McMahon, "The Land of the Model Husband—The Marshall Islands—The Atols of the Equator, etc."

THURSDAY, NOVEMBER 6...Royal Society and Royal Astronomical Society, Burlington House, W., 4.30 p.m. (Joint Meeting.) Discussion on "The Results of the Observations obtained at the Total Solar Eclipse on May 29th, 1919."

Linnean Society, Burlington House, W., 5 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Mr. O. A. Minns, "How to Make 'English' live in Child-mind."

Chemical Society, Burlington House, W., 8 p.m. 1. Messrs. F. G. Donnan and W. E. Garner, "Equilibria across a copper ferrocyanide and an amyl alcohol membrane." 2. Messrs. R. R. Le G. Worsley and P. W. Robertson, "The peroxides of bismuth." 3. Messrs. T. M. Lowry and R. G. Early, "The properties of ammonium nitrate. Part I.—The freezing-point and transition-temperatures." 4. Mr. R. H. Vernon, "Organic derivatives of tellurium. Part I.—Dimethyltelluroniumdiiodide." 5. Messrs. J. Reilly and W. J. Hickinbottom, "Intramolecular rearrangement of the alkylarylamine. Formation of 4-Amino-*n*-butylbenzene." 6. Mr. H. Swann, "A new modification of 3.4.dinitro-dimethylaniline." 7. Mr. G. Le Bas, (*a*) "The refractivities of unsaturated substances"; (*b*) "The molecular refractions of benzen and aromatic derivatives." 8. Messrs. R. R. Baxter and R. G. Fargher, "Some 1:3-benzodiazolearsinic acids and their reduction products."

University of London, University College, Gower-street, W.C., 5.30 p.m. Professor Antonio Cippico, "La Poesia di Giovanni Pascoli." (Lecture I., in Italian.) Mr. Im Bjorkhagen, "Selma Lagerhof." (Lecture I.)

China Society, School of Oriental Studies, Finsbury-circus, E.C., 5 p.m. Sir E. D. Ross, "Far Eastern Studies."

FRIDAY, NOVEMBER 7...Technical Inspection Association, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.30 p.m.

University of London, University College, Gower-street, W.C., 8 p.m. Professor G. D. Hicks, "An Introduction to Modern Philosophical Thinking." (Lecture I.)

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. W. Rawlings, "Some Things seen in Holland."

Philological Society, University College, W.C., 8 p.m. Professor H. G. Fiedler, "A Contemporary of Skakespeare in the Pronunciation of English and Latin."

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E. 1, and published for the ROYAL SOCIETY OF ARTS by G. BELL & SONS, LTD., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—October 31, 1919.

No. 3494. NOVEMBER 7, 1919. Vol. LXVII.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

// Journal of the Royal Society of Arts.

No. 3,494. VOL. LXVII.

FRIDAY, NOVEMBER 7, 1919.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

ARRANGEMENTS FOR THE SESSION 1919-20.

Particulars of the arrangements for the forthcoming session have been posted to all Fellows of the Society. Any Fellows who have not yet received them are requested to communicate with the Secretary.

HOURS OF MEETINGS.

The Council have decided that during the forthcoming session the Ordinary Meetings shall continue to be held on Wednesdays at 4.30 p.m. The Cantor Lectures will be given on Monday evenings at 8 p.m., the hour at which they were delivered before the war.

"OWEN JONES" PRIZES.

The Council are now prepared to offer six prizes in 1920 for the following subjects: Domestic Pottery and Table Glass; Metalwork, including work in Precious Metals, Ironwork, Jewellery, Enamelling, etc.; Textiles, including Lace, Embroideries, Openwork, Dress Brocades, Dress Designs and Costume Accessories (including Fans), Printed Fabrics for Dress.

Each prize will consist of the Society's Bronze Medal and a copy of a book or books on Applied Art, of a value not exceeding £2, to be selected by the successful competitor. In addition to the above prizes, the Council offer a special prize of £20 for the best design (irrespective of class) submitted for competition.

The Council reserve the right of withholding any or all of the prizes offered, and they will be the sole judges in each individual case of the qualifications of a competitor to receive an award.

The competition is limited to students of Schools of Art.

No competitor may send in more than a single design for each of the above-named manufactures, but that design may be accompanied by one or two working drawings or other illustrative sketches.

A sample of manufacture executed from the design may be submitted with, or in substitution for, the original design; but every submitted work must be approved by the master or other authority of the student's school, who must also certify that the design is the work of the student sending it in, and that it has been executed since the last competition in which the subject of the design was prescribed.

No candidate who has already received an Owen Jones prize for any of the above-named manufactures can take part in the competition.

Competing designs must be sent, carriage paid, and labelled "Owen Jones Prize Competition" on the outside, to the Director and Secretary, Victoria and Albert Museum, South Kensington, S.W. (7), between June 21st and June 26th, 1920. They may be delivered by hand on any one of the three days ending June 26th.

The sender must also notify the Secretary of the Royal Society of Arts by post that the design has been sent in, and must enclose stamps or P.O.O. for the return carriage.

No special conditions are laid down as to the size or character of the drawings sent in.

The awards will be made by the Council of the Royal Society of Arts on the recommendation of judges appointed by them.

Arrangements will be made, if possible, for the public exhibition of the competing designs in the Victoria and Albert Museum, South Kensington, as in previous years.

All possible care will be taken of the designs, but the Council accept no responsibility for injury or loss.

EXAMINATIONS, 1919.

It will be seen from the diagram on page 785, showing the progress of the Society's Examinations from the beginning of the century, that the increase in the number of entries which recurred in 1917 after the falling off in 1915 and 1916 in consequence of the war, has been maintained this year, the total being 31,132, as compared with 28,879 in 1918, and 24,221 in 1917. In last year's report it was anticipated that there would be a very substantial rise in the figures this year as, at the request of the War Office, arrangements were being made to hold in February last special examinations for troops on active service. The sudden collapse of the enemy, and the consequent demobilisation of large numbers of our forces, led to the almost complete abandonment of these arrangements. Examinations were indeed held at several centres when 245 entries were received; but so great was the dislocation caused by the uncertainties of the military situation that only 95 papers were worked. The following table shows the subjects selected and the results:—

Subject.	Stage.	Papers worked.	Passed.
Arithmetic . . .	I.	8	7
Book-keeping . .	I.	34	19
,, . .	II.	12	6
French	II.	21	15
,, ...	III.	20	16
		95	63

The usual examinations were held at two periods, April and May–June, as has been the case since 1915. In April the number of candidates was 10,886, and in May–June 20,246. The number of papers worked were divided between the two examinations as follows:—

	April.	May-June.	Total.
Advanced Stage .	772	2,538	3,310
Intermediate Stage	3,130	8,540	11,670
Elementary Stage.	6,984	9,168	16,152
	10,886	20,246	31,132

In addition to the 24,704 candidates who entered for the written examinations, 351 presented themselves for the *vivâ voce* examinations in modern languages. The total number of all candidates examined by the Society in 1919 was therefore 25,150.

No changes of importance were made in the examinations programme this year. The subjects were: Arithmetic, English, Book-keeping, Shorthand, Précis-writing, Typewriting, Economic Geography, Economic History, Economic Theory, Commercial Law, Company Law, Accounting, Banking, Theory and Practice of Commerce, Commercial Correspondence and Business Knowledge, English for Foreigners, French, German, Italian, Spanish, Russian, Dutch, Danish and Norwegian, Rudiments of Music, and Harmony. With regard to the future the Council have decided to discontinue the examinations in English for Foreigners, Rudiments of Music, and Harmony. The first-named examination was instituted in 1916, when it was suggested by the Bradford educational authority that such an examination would be useful to a number of Belgian refugees in this country. In that year the entries were 547. In 1917 the number dropped to 260, in 1918 to 195, and this year to 93. The examination was, of course, only designed as a war-time measure, and fortunately the need for it has ceased.

As for the examinations in Rudiments of Music and Harmony, the entries in these subjects have for some time been small, and as the ground is well covered by other bodies more directly concerned with musical education, the Council have decided to discontinue them.

In Arithmetic the total number of papers worked was 2,814, as compared with 2,743 last year. 83 candidates entered in Stage III., of whom only 8 obtained first-class certificates, 21 obtained second-class certificates, and 54 failed. These results, like those of last year, are exceedingly poor, and bear out the Examiner's opinion that the majority of these candidates "were ill-advised to enter for Stage III." The results in the other two stages are more satisfactory. In Stage II., of 616 candidates 55 obtained first-class certificates, 301 obtained second-class certificates, and 260 failed. In Stage I., of 2,115 candidates, 1,338 passed and 777 failed.

The increase in the number of entries in English, which last year was considerably higher than in any previous year, has been maintained, the figures being 1,169 as compared with 1,074. In Stage III., of 48 candidates 6 obtained first-class certificates, 24 second-class certificates, while 18 failed. In Stage II.,

of 324 candidates 51 obtained first-class certificates, 183 obtained second-class certificates, while 90 failed. In Stage I., of 797 candidates 464 passed, and 333 failed. On the whole the general standard of work appeared to be about normal.

Book-keeping has for many years been the most popular subject of the Society's examinations. In 1918 the entries numbered 8,023; this year they were 9,151. Of these 1,139 entered in Stage III.; 144 obtained first-class certificates, 528 obtained second-class certificates and 467 failed. In Stage II. there were 3,385 entries; 322 obtained first-class certificates, 2,050 obtained second-class certificates, and 1,013 failed. In Stage I. there were 4,627 entries; 2,895 passed and 1,732 failed. The Examiner reports that while the average merit of the work submitted shows little change from that of the past two years, several of the leading candidates showed exceptional merit.

Shorthand, as usual, comes next to Book-keeping in popularity. The entries totalled 8,202, as compared with 7,527 in 1918. 585 candidates entered for Stage III., of whom 53 obtained first-class certificates, 241 obtained second-class certificates, and 291 failed. 4,224 entered for Stage II.; of these 698 obtained first-class certificates, 1,704 obtained second-class certificates, and 1,822 failed. 3,393 entered in Stage I.; and of these 2,480 passed, while 913 failed.

The number of entries in Typewriting, 3,011, shows an increase of 422 over last year's total, and the results are extremely satisfactory. Reporting on the work for the Stage III. examination the Examiner writes: "During the nineteen years I have had the honour of filling the responsible position of Examiner to the Society, in which period I have scrutinised nearly 42,000 scripts, I have never handled better worked papers than those submitted at this year's examination." The standard of the work in Stages II. and I. was also good.

In last year's report regret was expressed that, in view of the enormously wide distribution of the British Empire and of its extremely varied interests, the subject of Economic Geography did not attract more students. The entries for 1918 (206) were indeed more than double those of 1917 (98), but the increase has not been continued; indeed, this year there is a very trifling falling off, the figure for 1919 being 202. Only 10 candidates entered for Stage III.; there were 62 entries for Stage II. and 130 for Stage I. Teachers as well as candidates would do well to devote careful attention to the reports of the Examiner in this subject.

In Economic History, again, the entries are very few. In Stage III. there were only 7, as compared with 13 last year. The standard, however, was high, and no fewer than 5 obtained first-class certificates, while the other two secured second-class certificates. In Stage II. there was a decided increase in the number of entries, 40 as against 16 in 1918; but unfortunately the quality of the work was very poor, only 3 obtaining first-class certificates, 18 second-class certificates, and 19 failing.

As was the case last year, there were more candidates for the Stage III. examination in Economic Theory than for Stage II., the respective numbers being 42 and 40; and—as was also the case last year—the work in Stage III. was generally very poor, only 4 first-class and 17 second-class certificates being awarded, while 21 failed. The work in Stage II. was a little better, though here, too, a large proportion of the papers sent in were of poor quality.

In Commercial Law there were 95 entries, as compared with 77 in 1918. 39 first-class and 48 second-class certificates were awarded, and the work generally was of a satisfactory standard. This was also the case in Company Law, where, out of 85 entries (as compared with 54 in 1918) 27 first-class and 41 second-class certificates were awarded.

The entries in Accounting rose to 179 from 142 last year. 28 obtained first-class, 78 obtained second-class certificates, and 73 failed. The Examiner reports that the work of the better candidates was creditable, although the percentage of failures was slightly higher than in 1918. In Banking there was a slight decrease in the number of entries—26 as compared with 37 last year; 4 obtained first-class and 11 obtained second-class certificates. As on previous occasions, many candidates showed that they possessed a good theoretical knowledge of the subject, but very little acquaintance with practical bank book-keeping.

The total number of entries for Theory and Practice of Commerce was 215, as compared with 210 in 1918. Of the 60 candidates in Stage III. only 3 obtained first-class certificates, 45 obtained second-class certificates, and 12 failed. In Stage II. the number of mediocre papers was also very high; of 155 candidates only 8 obtained first-class certificates, and 109 second-class certificates. The Examiner is of opinion

that "the majority of candidates, and presumably of teachers, take the view that this subject is one that calls chiefly for the accumulation of a large and miscellaneous collection of facts. This is, of course, the case up to a point, but candidates cannot expect to pass first-class unless they exhibit some indication of an ability to grasp the significance of the facts they have acquired. The subject is one that calls for more reflection than it appears to receive from the great majority of candidates."

The number of entries in Commercial Correspondence and Business Knowledge was 2,402, as compared with 2,430 in 1918, and 1,973 in 1917. In Stage III. 42 candidates entered, 5 gained first-class certificates, 15 second-class certificates, and 22 failed. In Stage II. 445 candidates entered, 24 obtained first-class certificates, 236 obtained second-class certificates, and 185 failed. In Stage I. of 1,915 candidates 1,221 passed and 694 failed. Commenting on the work in Stage II. the Examiner reports that, although no candidate qualified for a medal, the general standard is superior to any since the examination was inaugurated. There is still, however, a good deal of slovenly and inaccurate work submitted.

The entries in English for Foreigners dropped this year to 93, as compared with 195 in 1918. The largest entry was in 1916, when 547 candidates presented themselves. As has been already mentioned, the examination was instituted to meet the needs of Belgian refugees who had been driven by the war to seek shelter in this country. As practically all these refugees have now been repatriated, the Council have resolved to discontinue the examinations in this subject. That they have been appreciated is shown by the fact that during the four years in which they have been held 1,095 candidates have presented themselves for the written and 95 for the oral examinations.

There has been an increase of 179 in the entries for French, which number 2,427 (Stage III., 531; Stage II., 957; Stage I., 939), as compared with 2,248 in 1918. The Examiner is of opinion that the standard of the work is not as high as in former years. While the translations from French into English were satisfactory, those from English into French were poor: even in Stage III. the syntax was often faulty, and "the most elementary rules of accidence—plurals, verbs, adverbs generally — were neglected to a somewhat surprising degree."

The entries for German (202) show a slight increase on last year's figure (181), but this subject has a long way to go before it reaches its pre-war figures. In 1914 the total in all stages was 826; in 1915 this fell to 462, in 1916 to 270, in 1917 to 215, and in 1918 to 181. The Examiner reports very favourably on the work in Stage III., where of 46 candidates 20 obtained first-class certificates, and 19 second-class certificates. The work in Stage II., on the other hand, was poor, while in Stage I. out of 85 candidates 36 passed and 49 failed.

The entries in Italian are disappointing, as they show a decrease from 80 in 1918 to 47 this year. The standard of work, however, was satisfactory. In Stage III., 3 first-class, and 10 second-class certificates were awarded, and there were no failures; in Stage II., 5 first-class and 4 second-class certificates were awarded, and there was one failure; while in Stage I., 17 passed, and 7 failed.

The popularity of Spanish is growing, the entries in all stages being 386 as compared with 289 last year. This figure beats the highest pre-war total of 355. The standard of work in Stage III., however, was disappointing; of 64 candidates only one obtained a first-class certificate, 35 obtained second-class certificates, and 28 failed. In Stage II. the Examiner reports that the results are good, though here, too, he feels it necessary to emphasise the somewhat obvious fact that nothing can be done in any language without a knowledge of its grammar. On the whole, the work in Stage I. was most satisfactory, where there were only 57 failures out of 178 entries. It is to be hoped that this result in the Elementary Stage bodes well for future work in Stages II. and III.

In 1917 there was a distinct boom in Russian, when 266 candidates—by far the largest number on record—entered in all stages. Since then the interest in that unhappy country has declined. Last year the entries fell to 157, and this year there are only 79. Speaking generally, the candidates showed that they possessed good vocabularies, and that they had read a good many Russian books, but their knowledge of the grammar was defective. It is perhaps hardly to be expected that students will be attracted to the study of Russia as they were at the time when things were going well in that country and there were fair prospects of increased trade with it; but possibly some will be encouraged to attempt the study of an interesting if difficult language by the institution of

the "Russian Embassy Prize,"* founded in commemoration of the Russian soldiers and sailors who fell in the war.

After an interval of several years, examinations were again held in Danish and Norwegian; 4 candidates entered in Stage III., of whom 3 obtained first-class certificates, and one a second-class certificate. In Stage II., 10 entered, of whom 5 obtained first-class certificates, and 5 second-class certificates.

In Dutch, where the entries have always been few, only 4 candidates presented themselves in Stage II., and of these one obtained a second-class certificate, while the others failed.

The examinations in Rudiments of Music and Harmony, as has already been mentioned, were held this year for the last time. In the former subject 73 entered, of whom 24 obtained Higher certificates, 19 obtained Elementary certificates, and 30 failed. In Harmony 27 entered, 4 obtained Higher, 4 obtained Intermediate, 5 obtained Elementary certificates, and 14 failed.

Oral examinations were held in French, German, Italian, Spanish and Russian. The total number of candidates was 351 (as compared with 256 last year), of whom all (except 16 who were examined at Manchester and 17 at Coventry) presented themselves at various centres in London. The numbers in the different languages were: French 271, German 27, Italian 10, Spanish 25, Russian 18. The details of the results of the oral examinations are given in Table B (page 787).

The number of entries for the oral examinations has never been large, compared with those for the written examinations in modern languages, the highest number yet reached being 688 in 1913. The Council feel that the time has now come when they ought to insist upon a colloquial knowledge of modern languages in the Advanced Stage, and accordingly they have decided that in and after 1921 oral examinations will be compulsory in the Stage III. Examinations in French, German, Spanish and Italian.

The Court of the Clothworkers' Company have again renewed their grant of £40, to be expended in providing medals in all the subjects of examination where the work of candidates attains a sufficiently high standard. There is no doubt that these medals are highly valued by those who win them, and they have done much to maintain or raise the level of excellence in the papers worked. This year the Society has awarded 20 Silver Medals in the Advanced Stage, and 35 Bronze Medals in the Intermediate Stage.

The Examination Syllabus for 1920 has been issued. In it will be found the fullest possible information about the examinations, a syllabus of each stage of each subject, and a list of centres. The papers set in April and May–June, 1919,* have been reprinted in six pamphlets. Each pamphlet contains, in addition to the papers of each stage, the syllabuses of the subjects in the pamphlet and the Examiners' reports on the papers worked in 1919. The attention of both teachers and students may be drawn once more not only to the syllabuses but also to the remarks of the various examiners on the results of last year. It will be found that these contain many valuable and helpful suggestions, and the work of the candidates year after year shows that far too little attention is paid to them. Teachers especially are earnestly recommended to study these reports, as they ought to be guided by them in the instruction they give to their pupils.

The regulations for the Viva Voce Examinations in Modern Languages are also given at full length in the syllabus.

In order to encourage the study of Typewriting and Shorthand, and to assist in ensuring the supply of efficient and educated shorthand typists, the Proprietors of the *Daily Sketch* have decided to offer a sum of £1,000 in prizes in connection with the Society's Examinations in 1920. In the Advanced Stage the prizes amount to £675, the first prize being £250; in the Intermediate Stage the prizes amount to £250, the first prize being £60; and in the Elementary Stage the prizes amount to £75, the first being £10. The subjects of examination in each stage are Typewriting, Shorthand, and English. These will be taken at the Society's ordinary examinations in March and May, 1920. In the Elementary Stage the prizes will be awarded on the result of these examinations without any further test. In the Advanced and Intermediate examinations a number of candidates will be selected to compete for the prizes, and they will then be required to come to London for a final test. Full particulars of the scheme will be found in the Syllabus.

* The prize, which will take the form of books to the value of £5, will be awarded annually to the candidate (under the age of twenty-five) who secures the highest number of marks in the Advanced Stage.

* The price of the Syllabus for 1920 is 3*d*. post free. Copies can be obtained on application to the Examinations Officer Royal Society of Arts, Adelphi, London, W.C. (2) The price of the pamphlets containing the 1919 papers is 3*d*. each, post free. Particulars of these may be obtained as above.

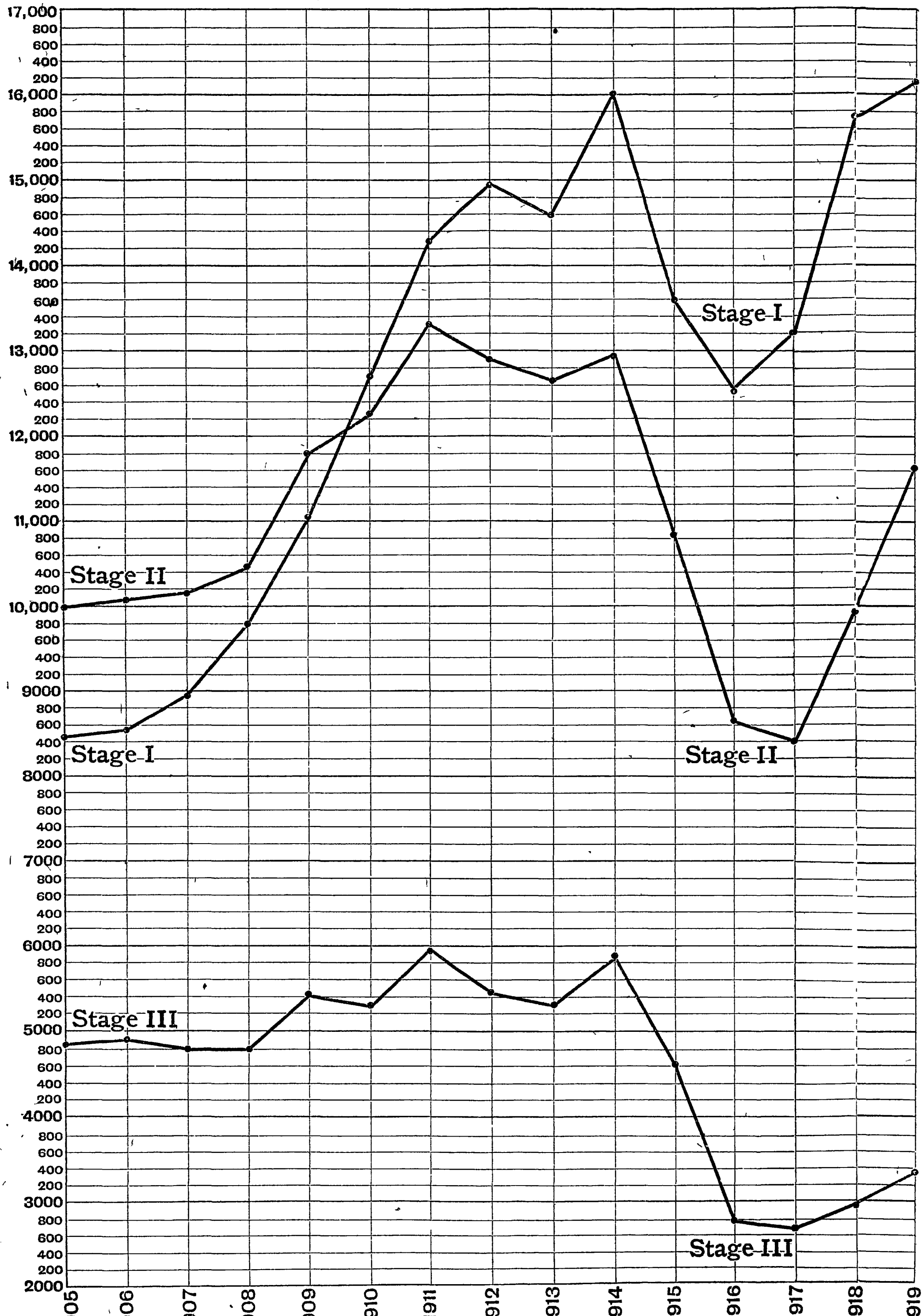


DIAGRAM SHOWING THE NUMBERS OF PAPERS WORKED IN THE THREE STAGES, 1905-1919.— I. ELEMENTARY; II. INTERMEDIATE; III. ADVANCED.

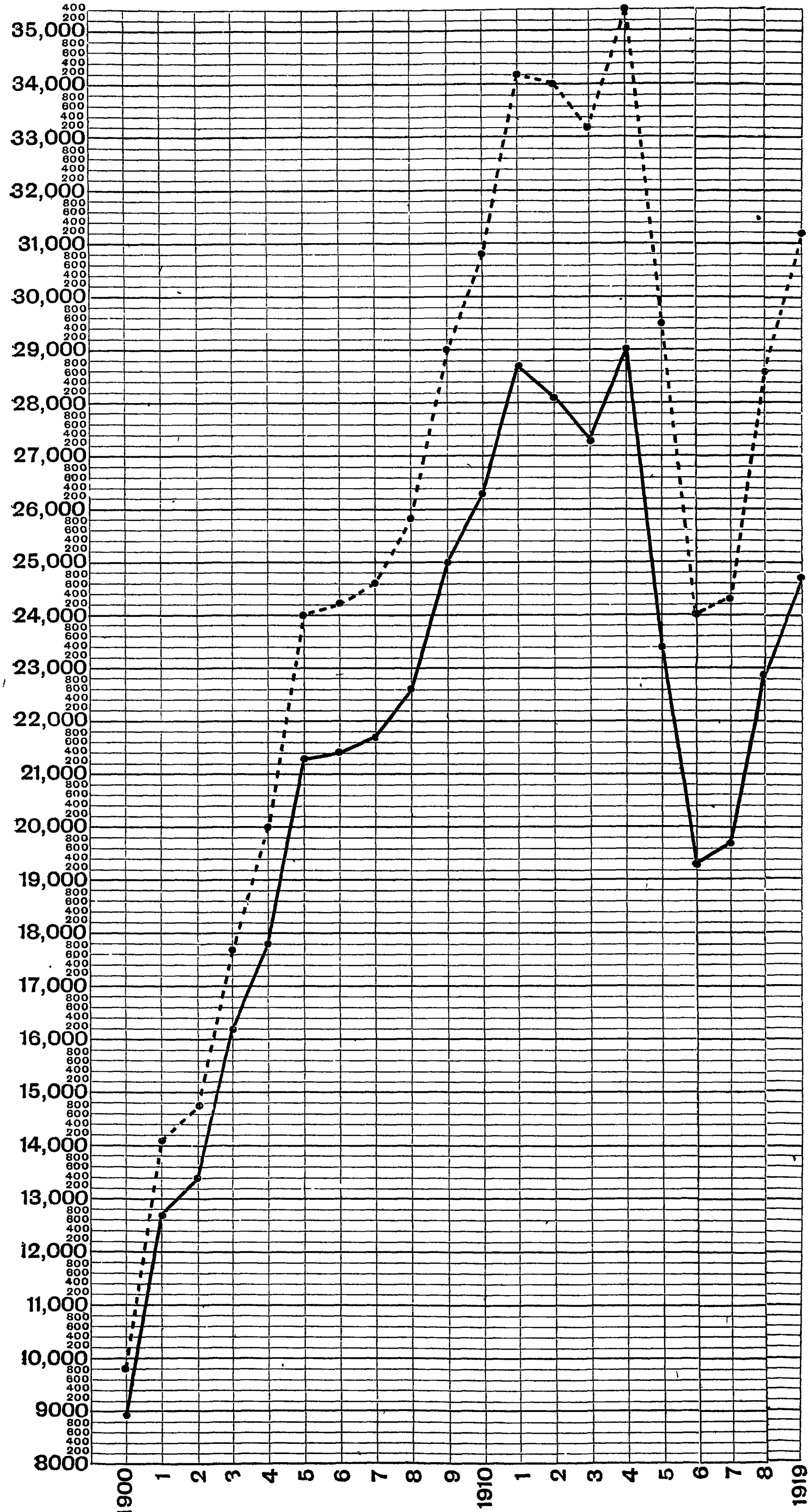


DIAGRAM SHOWING PROGRESS OF EXAMINATIONS, 1900–1919.

The continuous line shows the number of candidates, the dotted line the number of papers worked.

TABLE A.—DETAILS OF THE 1919 EXAMINATIONS.

SUBJECTS.	STAGE III.—ADVANCED.				STAGE II.—INTERMEDIATE AND MUSIC.							STAGE I.—ELEMENTARY.			Total number of papers worked in all stages.
								Music Certificates.							
	Papers worked.	1st-class certificates.	2nd-class certificates.	Not passed.	Papers worked.	1st-class certificates.	2nd-class certificates.	Higher.	Inter-mediate.	Elemen-tary.	Not passed.	Papers worked.	Passed.	Not passed.	
Arithmetic	83	8	21	54	616	55	301	..	..	..	260	2,115	1,338	777	2,814
English	48	6	24	18	324	51	183	..	..	..	90	797	464	333	1,169
Book-keeping	1,139	144	528	467	3,385	322	2,050	..	..	..	1,013	4,627	2,895	1,732	9,151
Economic Geography	10	1	4	5	62	..	41	..	..	..	21	130	83	47	202
Shorthand	585	53	241	291	4,224	698	1,704	..	..	..	1,822	3,393	2,480	913	8,202
Typewriting	182	64	97	21	944	302	450	..	..	..	192	1,885	1,311	574	3,011
English for Foreigners	19	9	7	3	34	9	12	..	..	..	13	40	20	20	93
Economic History	7	5	2	..	40	3	18	..	..	..	19	..	..	..	47
Economic Theory	42	4	17	21	40	7	27	..	..	..	6	..	..	..	82
Précis-writing	27	3	12	12	73	9	40	..	..	..	24	..	..	..	100
Commercial Correspondence and Business Knowledge	42	5	15	22	445	24	236	..	..	..	185	1,915	1,221	694	2,402
Commercial Law	95	39	48	8	..	..	..	..	..	..	..	..	..	..	95
Company Law	85	27	41	17	..	..	..	..	..	..	..	..	..	..	85
Accounting	179	28	78	73	..	..	..	..	..	..	..	..	..	..	179
Banking	26	4	11	11	..	..	..	..	..	..	..	..	..	..	26
Theory and Practice of Commerce	60	3	45	12	155	8	109	..	..	..	38	..	..	..	215
French	531	38	355	138	957	111	614	..	..	..	232	939	509	430	2,427
German	46	20	19	7	71	10	46	..	..	..	15	85	36	49	202
Italian	13	3	10	..	10	5	4	..	..	..	1	24	17	7	47
Spanish	64	1	35	28	144	13	88	..	..	..	43	178	121	57	386
Russian	23	3	10	10	32	6	16	..	..	..	10	24	13	11	79
Danish and Norwegian	4	3	1	..	10	5	5	..	..	..	..	..	..	..	14
Dutch	..	..	..	..	4	..	1	..	..	..	3	..	..	..	4
Rudiments of Music	..	..	..	..	73	..	..	24	..	19	30	..	..	..	73
Harmony	..	..	..	..	27	..	..	4	4	5	14	..	..	..	27
Totals	3,310	471	1,621	1,218	11,670	1,638	5,945	28	4	24	4,031	16,152	10,508	5,644	31,132

TABLE B.

VIVA VOCE EXAMINATIONS HELD DURING 1919.

Centre of Examination.	Date.	Number of Candidates.	Passed with Distinction.	Passed.	Failed.
French :—	1919.				
Coventry Municipal Technical Institute	May 5	17	3	10	4
Kensington College	May 20	19	2	10	7
Enfield Technical Institute	May 21	45	12	25	8
Kensington College	May 23	16	9	6	1
Manchester Education Committee	May 28	9	4	4	1
City of London College (Candidates from London Institutions)	June 11	20	4	9	7
Pitman's School	June 12	24	10	11	3
City of London College	June 13	14	—	9	5
"Hugh Myddelton" L.C.C. Institute (Candidates from L.C.C. Institutes)	June 16 & 17	44	18	12	14
"Oliver Goldsmith" L.C.C. Institute (Candidates from L.C.C. Institutes)	June 18	22	10	9	3
"Hugh Myddelton" L.C.C. Institute (Candidates from L.C.C. Institutes)	June 23	17	11	4	2
Regent Street Polytechnic (Candidates from London Institutions)	June 24	24	4	11	9
German :—					
Regent Street Polytechnic (Candidates from London Institutions)	June 19	27	8	12	7
Italian :—					
"Hugh Myddelton" L.C.C. Institute (Candidates from L.C.C. Institutes)	June 26	10	3	6	1
Russian :—					
City of London College (Candidates from London Institutions)	June 25	18	2	10	6
Spanish :—					
Manchester Education Committee	May 27	7	2	2	3
City of London College (Candidates from London Institutions)	June 18	18	1	13	4
	Totals	351	103	163	85

FLAX-GROWING WITHIN THE EMPIRE.

Early in 1918 the Board of Trade appointed a representative Committee "to investigate in all its bearings the question of increasing the supply of flax in the British Empire." On May 7th last the Committee presented an interim report, which has now been issued as a White Paper [Cmd. 281]. The report is signed by Lord Colwyn (Chairman), Sir Frank Warner (Vice-Chairman), Messrs. A. Abbott, W. Norman Boase (Scottish Flax Spinners' and Manufacturers' Association), J. A. Calder, J. R. Campbell, R. Garrett Campbell, D. T. Chadwick (Indian Trade Commissioner), Andrew Fisher (High Commissioner for Australia), W. L. Griffith (Permanent Secretary, Department of the High Commissioner for Canada), Philip Guedalla, Sir Thomas Mackenzie (High Commissioner for New Zealand), and Sir Thomas Middleton (Assistant Secretary, Board of Agriculture).

Previous to the war our manufacturers required annually some 100,000 tons of this important fibre. Seventy to eighty thousand tons came from Russia and 10,000 tons from Belgium, France, and Holland, while Ireland contributed 10,000 tons, and the rest of the United Kingdom 2,000 tons.

Until a century ago flax was produced on a considerable scale in practically all parts of these isles. In England and Scotland the industry was destroyed by Russian competition and other economic causes. Much later

cultivation in Ireland also declined for similar reasons but did not cease to exist. The serious effects of the war on the British linen trade are well known. The flax-growing districts of Belgium and France were the first to be overrun by the Germans; supplies from Holland soon diminished, and then, in 1917, followed the Russian collapse. These conditions have led to a marked development of flax-production in Ireland, as well as in Scotland and in England. The outlook, however, is far from satisfactory, and the linen trade is still threatened by shortage of raw material. Given a supply of seed, says the Committee, excellent flax can be grown in many parts of the Empire. This country itself is probably unsurpassed both in soil and climate for the purpose; but if there is to be any permanent increase of the acreage under flax there must be an entire change in the system of growing and handling. At present what the grower sells in Ireland is not simply raw material, but a partly-manufactured article. The flax should be bought from the farmer "on foot," *i.e.*, as a standing crop, or delivered pulled and dried, the whole process of retting and scutching being undertaken by the purchaser. A really good pulling machine is needed. Flax ought to be pulled, not cut, and the difficulty of obtaining sufficient hands at a time when other crops are ready for harvesting has been so great as to necessitate special arrangements for obtaining imported temporary labour. The measures adopted at great expense during the war would not be available, even if they were profitable, in peace time. Hence the necessity of some mechanical means by which the labour difficulty can be surmounted.

Describing what actually has been done recently to secure a larger production in our own agricultural districts, the Committee gives some encouraging figures. In Ireland, in 1914, there were 49,000 acres under flax; in 1918 the number of acres had risen to 143,000, and would have been even higher but for a scarcity of seed and insufficient instructors. Flax-growing in Ireland is mainly confined to the north, but a very great extension is possible outside Ulster, and already there has been notable expansion. In Cork the area devoted to flax rose from 209 acres in 1914 to 3,053 acres in 1918, and in Mayo and Sligo from 241 acres to 1,688. It is considered most desirable that in the south of Ireland the crop should be handled on factory lines. The position in England and Scotland was fully set forth in the recently-published report of the Flax Production Branch of the Board of Agriculture.*

The provision of seed, it is pointed out, will not cease to be the cause of grave anxiety and considerable expense until a safe and satisfactory supply can be secured within the Empire. This is considered to be a commercial possibility. At the outbreak of war, home growers were dependent upon Russia and Holland. The emergency measures which consequently became necessary included the introduction of large quantities of Japanese seed.

The flax-growing possibilities of British East Africa, India, Canada, and Australasia, are briefly reviewed in the report, and the Committee summarises the conclusions at which it has arrived. Its recommendations are as follows:—

General.—It is undesirable that an industry so important as the British Linen Trade should remain largely dependent upon external sources of supply for its raw material, especially as the industry has proved to be indispensable in war time. The efforts made by the Government under the necessity of abnormal war conditions to foster the revival of flax-growing in the United Kingdom, and to extend its cultivation within the Empire have achieved a considerable measure of success, and it is essential that these efforts should be continued until full value has been derived from them.

Great Britain.—The efforts made under the stress of war conditions to revive flax-growing in England and Scotland have been essentially experimental in their character, the main point being to determine whether under modern conditions, including the use of machinery and the central retting process, it is possible to re-establish the industry on a large scale and on a sound economic basis. In Great Britain it is desirable that this work should be continued until sufficient data are accumulated to provide a definite answer to this question. In the event of the result of these experiments being unfavourable to the continuanc of the English and Scottish schemes on an economic basis, the question will still remain whether part of the area and of the establishment should be retained for further experimental purposes on the lines of purely scientific research. Research should be undertaken into the possibilities of further mechanical improvements in the means of cultivating and handling flax.

Ireland.—The Department of Agriculture and Technical Instruction should at once take steps to develop and extend their existing schemes for the encouragement of flax-growing in Ireland, and for this purpose they should be provided with funds to enable them: (1) to provide further instruction in the cultivation and handling of the crop, and to

* *Journal*, Vol. LXVII. p. 651.

devote special attention to the new districts where instruction is most needed; (2) to continue and extend their investigations into the selection, improvement and supply of the varieties of seed best suited to Irish conditions, and other questions affecting the growing of flax in Ireland; (3) to make permanent provision for the training of instructors and scutchers; (4) to give loans for the erection of new, and for the repair and extension of existing, scutch-mills.

The work of the Flax Society may also be regarded as mainly an experiment directed to the same problem as that of the English and Scottish schemes, and should in the same way be continued for such time as is necessary to secure its full experimental value. It is of the first importance that an experiment should be made on a sufficiently large scale to test the feasibility of reviving the flax-growing industry in the south of Ireland on factory lines, and for this purpose at least two units of the area of 1,000 acres each should be established in the south, as already recommended by the Committee.

Canada.—The scheme for the supply of fibre seed from Western Canada should be continued until such a time as, owing to the return of normal conditions or the development of other sources of supply, the question of seed supply for the United Kingdom is put on a permanently satisfactory basis.

British East Africa.—The results already achieved in British East Africa warrant the hope that success in this area is likely to be permanent. That nothing may be lacking on the part of the authorities to ensure this success, we recommend: (1) the provision at central points of machinery for the treatment of flax; (2) the development of agricultural research and experiment in flax production in the Protectorate by such means as after suitable investigation the local Department of Agriculture may suggest; and (3) the provision of expert assistance in the preparation and grading of flax for the market. The scheme for the settlement of slightly disabled soldiers in British East Africa should be adopted, and if successful should be made the first of other schemes for the settling of soldiers in this colony, where the conditions seem to be peculiarly favourable to the production of flax.

WEST INDIAN SHIPPING.

A year ago the Secretary of State for the Colonies appointed a representative Committee to consider the probable effect of the shipping position after the war on British trade with our West Indian Colonies and on inter-colonial communications, and to report what, if any, measures should be taken to maintain adequate communication with and between those Colonies, and to provide increased port or other facilities for shipping. The report of the Committee was recently presented to Lord Milner, and has now been printed, as a Parliamentary paper [Cmd. 372]. The Committee recommend that a direct mail and passenger service, with a fixed time-table, be established as soon as possible, and be maintained between this country and the Lesser Antilles and British Guiana; that tenders be called for within a year for both a three-weekly and a fortnightly service; that every effort be made to open up and develop British Guiana; that Trinidad is, on the whole, the most convenient port of transhipment for any branch services; that if possible a joint policy be adopted by the British and Canadian Governments, so as to allow of a continuous service by way of the West Indies between Canada, and the United Kingdom; that if direct communication between Jamaica and the British Isles can be secured by the diversion of some service proceeding through the Panama Canal a small subsidy would be worth paying; that every support should be accorded to such efforts as the Canadian Government may make to open or maintain steamship communication between the Dominion and Bermuda, the Bahama Islands, Jamaica, and British Honduras; that no attempt can at present be made with advantage by the Governments concerned to institute air services at their own expense, but that any experiments undertaken by private enterprise be watched with a view to gaining experience; and that any measures possible should be taken in order to improve the accommodation on board ship for the labourers who travel locally between the West Indian islands.

The Committee also urge that such action as is practicable be taken upon the suggestion they make in the report regarding the French and Venezuelan surtaxes. The French surtax obliges steamers carrying cargo to France to make a French port their first port of call, and thereby encourages the transhipment trade of France as against that of this country. The Venezuelan surtax also has an unfavourable effect upn the transhipment trade of the West Indies.

GENERAL NOTES.

Lost Contracts.—How serious are the disabilities under which British manufacturers are labouring is once again demonstrated, says the "*Times*" *Trade Supplement*, by the loss of an order for turbo-alternators required by the Edinburgh Corporation. The Council received sixteen tenders for the contract, the three lowest coming from Swiss firms. The lowest British tender amounted to £174,075, whereas one of the Swiss firms offered to carry out the contract for £106,618. The Council frankly stated that they could not give a premium of nearly £70,000 for machines of British manufacture, and, acting on the recommendation of their expert adviser, they accepted the foreign offer. It is very improbable that even if any of the British firms could have done the work without any profit, they could have approached the

foreign offer. It is reported that one of the British tenderers intends to post the terms of the contract in a prominent place in his works for his workmen to read.

COMMERCIAL TRAVELLERS ON NAVAL SHIPS.—An interesting departure was announced by the Parliamentary Secretary of the Overseas Trade Department, Sir Hamar Greenwood, M.P., at a luncheon given on October 29th by the Association of British Chambers of Commerce. Owing to the difficulty experienced at the present time in securing berths in the ordinary passenger boats, he approached the First Lord of the Admiralty, Mr. Walter Long, with the request that every warship sailing for ports abroad should be allowed to carry a certain number of commercial travellers and other representatives of British firms. Mr. Long has personally agreed. "It now remains," Sir Hamar Greenwood continued, "for the First Lord of the Admiralty to convince the Sea Lords of the Board of Admiralty that they can serve this country in no better way than by carrying commercial travellers to the uttermost parts of the earth."

STATE PURCHASE OF HYDRO-ELECTRIC WORKS.—The Horahora hydro-electric works erected a few years ago by the Waihi Gold Mining Company, and described as one of the best plants in New Zealand, have been purchased by the Dominion Government. The company's own maximum demand is 4,000 h.p. The remainder, 8,000 h.p., will be distributed by the Government throughout the Waikato and adjacent districts as far as Auckland. The latter is slightly over one hundred miles from Horahora. The Government had the right to take this property at any time without payment of goodwill at a valuation fixed by agreement or arbitration, and it is said that they have acquired it at the absolute cost price, £212,500.

UNDERGROUND RAILWAY FOR MARSEILLES.—The British Consul-General at Marseilles reports that the Municipal Council of that city has decided to undertake the construction of an underground railway, so much needed by the ever-increasing congestion of the streets. It is understood that no time will be lost in obtaining the necessary Government sanction and in proceeding with the work.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 10...Swiney Lectures, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Dr. J. D. Falconer, "The Geology and Mineral Resources of the British Possessions in Africa." (Lecture I.)

Surveyors' Institution, 12, Great George-street, S.W., 8 p.m. Opening Address by Mr. A. Young (President).

Geographical Society, Kensington Gore, W., 5 p.m. Lieut.-Col. G. A. Beazeley, "Surveying in Mesopotamia during the War."

TUESDAY, NOVEMBER 11...University of London, University College, Gower-street, W.C., 5.30 p.m. Mr. J. H. Holweg, "Holberg and Ewald." (Lecture II.)

Physicians, Royal College of, Pall Mall East, S.W., 5 p.m. Dr. E. G. Browne, "The Origins and Development of Arabian Medicine. I.—The Translations (VII.-IX. Cent.)." (Fitzpatrick Lecture.)

Photographic Society, 35, Russell-square, W.C., 7 p.m. Presidential Address.

Anthropological Institute, 50, Great Russell-street, W.C., 8.15 p.m. Mr. S. H. Warren, "A Stone-Axe Factory at Penmaenmawr."

WEDNESDAY, NOVEMBER 12...Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m Dr. C. A. Swan, "Some Physical and Psychical Effects of Altitude."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor P. Abercrombie, "Town-Planning and Public Health."

Swiney Lectures, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Dr. J. D. Falconer, "The Geology and Mineral Resources of the British Possessions in Africa." (Lecture II.)

University of London, University College, Gower-street, W.C., 3 p.m. Dr. E. G. Gardner, "History and Drama in the Divina Commedia." (Lecture II.) 5.30 p.m. Mr. H. E. Palmer, "Methods of Learning Foreign Languages." (Lecture II.) Mr. I. C. Grondahl, "Holberg and Wessel." (Lecture II.) 6.15 p.m. Mr. J. C. Stamp, "Fundamental Principles of Taxation in the Light of Modern Developments." (Lecture II.)
7 p.m. Mr. J. J. Guest, "Guest's Law and Design (Civil and Mechanical Engineering)." (Lecture II.)

THURSDAY, NOVEMBER 13...Physicians, Royal College of, Pall Mall East, S.W., 5 p.m. Dr. E. G. Browne, "The Origins and Development of Arabian Medicine. II.—Four Great Medical Writers of Persia (IX.-XI. Cent.")." (Fitzpatrick Lecture.)

Auctioneers' and Estate Agents' Institute, 34, Russell-square, W.C., 4 p.m. Lord Montagu of Beaulieu, "Roads, Transport, and Values."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Inaugural Address by the President (Mr. R. T. Smith).

University of London, University College, Gower-street, W.C., 5.30 p.m. Professor A. Cippico, "La Poesia di Giovanni-Pascoli." (Lecture II., in Italian.) Mr. Im. Bjorkhagen, "Selma Lagerlof." (Lecture II.)

FRIDAY, NOVEMBER 14...London Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m.

Swiney Lectures, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Dr. J. D. Falconer, "The Geology and Mineral Resources of the British Possessions in Africa." (Lecture III.)

Astronomical Society, Burlington House, 5 p.m.

University of London, University College, Gower-street, W.C., 8 p.m. Professor G. D. Hicks, "An Introduction to Modern Philosophical Thinking." (Lecture II.)

Sanitary Institute, Town Hall, Bootle, 7 p.m. Dr. E. W. Hope, "Reconstruction of the Public Health Services."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. 1. Mr. S. Butterworth, "On the Self-Inductance of Single Layer Flat Coils." 2. Dr. N. W. McLachlan, "An Experimental Method of Determining the Primary Current at Break in a Magneto." 3. Mr. F. W. Newman, "Note on a Modified Form of Wehnelt's Interrupter."

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. W. Sanderson, "Southern Italy.'

No. 3495. NOVEMBER 14, 1919. Vol. LXVII.

JOURNAL
OF THE
ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.2

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about 3,500 Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

London: Printed by William Clowes & Sons, Ltd., Duke Street, Stamford Street, S.E. 1, and published for the Royal Society of Arts by G. Bell & Sons, Ltd., York House, Portugal Street, W.C. 2, in the Parish of St. Clement Danes, in the City of Westminster.—November 7, 1919.

Journal of the Royal Society of Arts.

No. 3,495. VOL. LXVII.

FRIDAY, NOVEMBER 14, 1919

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

ARRANGEMENTS FOR THE SESSION.

The Opening Meeting of the One Hundred and Sixty-Sixth Session will be held on Wednesday, November 19th, at 4.30 p.m., when an address will be delivered by SIR HENRY TRUEMAN WOOD, M.A., Vice-President and Chairman of the Council. The subject of the address will be "Science and Industry."

The following arrangements have been made for the meetings before Christmas :—

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

NOVEMBER 26.—H. B. MORSE, LL.D., late Statistical Secretary, Imperial Maritime Customs, "British Trade in China." BYRON BRENAN, C.M.G., late H.B.M. Consul-General, Shanghai, will preside.

DECEMBER 3. — JOHN WESTALL PEARSON, Chairman and Director, British Oil and Cake Mills, "The Oil Seed Crushing Industry." The Right Hon. LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

DECEMBER 10.—SIR OLIVER LODGE, D.Sc., Sc.D., LL.D., F.R.S., "Some Possible Sources of Energy." (Trueman Wood Lecture.)

DECEMBER 17.—CONSTANTINE GRUNEWALD, late Chief of Intelligence Department, Russian Ministry of Trade and Industry, "The Present Economic Position of Russia, and some Aspects of its Future Development."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m. :—

DECEMBER 9.—SIR EDWARD DAVSON, President of the Associated West Indian Chambers of Commerce, "Problems of the West Indies." LIEUT.-COLONEL L. S. AMERY, M.P., Under-Secretary of State for the Colonies, will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.

DECEMBER 18.—P. J. HARTOG, C.I.E., M.A., Member of the Calcutta University Commission, 1917–1919, "Some Problems of Indian Education."

Papers to be read after Christmas :—

BRIGADIER - GENERAL EDWARD MAITLAND, D.S.O., "The Commercial Future of Airships."

SIDNEY PRESTON, C.I.E., "English Canals and Inland Waterways."

BRIGADIER - GENERAL SIR HENRY P. MAYBURY, K.C.M.G., C.B., M.Inst.C.E., "Road Transport."

CHARLES H. SHERRILL, "Stained Glass."

ALFRED E. HAYES, General Secretary, English Language Union, "The English Language and International Trade."

JAMES CURRIE, C.M.G., Ministry of Labour (Training Department), late Principal, Gordon Memorial College, Khartoum, "Industrial Training."

LADY INGLEFIELD, President, Buckinghamshire Lace Association (North Bucks and Bedfordshire), "The Hand-made Lace Industry."

GRAILY HEWITT, "Rolls of Honour."

ALFRED H. POWELL, "Ancient Cottages and Modern Requirements." The Right Hon. EARL FERRERS will preside.

CHARLES CROWTHER, "The Arts and Crafts of Japan" (with examples from the author's private collection).

SIR CECIL HERTSLET, late H.M.B. Consul-General for Belgium, "The Ruin and Restoration of Belgium." EMILE CAMMAERTS will preside.

BRIGADIER - GENERAL LORD MONTAGU OF BEAULIEU, C.S.I., "Motor Transport in India."

SIR GEORGE CUNNINGHAM BUCHANAN, K.C.I.E., M.Inst.C.E., "The Ports of India: their Administration and Development."

SIR JOHN HUBERT MARSHALL, C.I.E., M.A., Litt.D., F.S.A., Director-General of Archæology in India, "Recent Archæological Discoveries in India."

SIR VALENTINE CHIROL, Sir George Birdwood Memorial Lecture.

SIR FRANCIS WATTS, K.C.M.G., D.Sc., Imperial Commissioner of Agriculture for the West Indies, "Tropical Departments of Agriculture, with special reference to the West Indies." LIEUT.-COLONEL SIR DAVID PRAIN, C.M.G., C.I.E., LL.D., F.R.S., Director of the Royal Botanic Gardens, Kew, will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

January 15, February 19, March 18, April 15, May 20.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

February 3, March 2, May 4.

CANTOR LECTURES.

Monday evenings, at 8 p.m.:—

JOHN THEODORE HEWITT, M.A., D.Sc., Ph.D., F.R.S., Emeritus Professor of Chemistry, East London College, "Synthetic Drugs." Three Lectures.

December 1, 8, 15.

CAPTAIN H. HAMSHAW THOMAS, M.B.E., M.A., F.G.S., Fellow of Downing College, Cambridge, and formerly of the Royal Air Force, "Aircraft Photography in War and Peace." Three Lectures.

January 19, 26, February 2.

CHARLES FREDERICK CROSS, B.Sc., F.R.S., F.C.S., "Recent Research in Cellulose Industry." Three Lectures.

February 16, 23, March 1.

WALTER ROSENHAIN, B.A., D.Sc., F.R.S., Superintendent, Department of Metallurgy and Metallurgical Chemistry, National Physical Laboratory, "Aluminium and its Alloys." Three Lectures.

April 12, 19, 26.

ARTHUR THOMAS BOLTON, F.R.I.B.A., F.S.A., Curator, Soane Museum, "The Decoration and Architecture of Robert Adam and Sir John Soane, 1785–1837." Three Lectures.

May 3, 10, 17.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m.:—

LOUGHNAN PENDRED, M.I.Mech.E., Editor of *The Engineer*, "Railways and Engines."

January 7, 14.

CHINESE INDUSTRIES.

A correspondent of the *Times* of September 20th contributes an interesting article dealing with various industries in China, in the course of which he points out that, whilst the natural resources of the country are practically unlimited, "everything is wrong in China because there is no Government, and, worse, because there seems no prospect of a resurrection of the art of governing." The trade in tea, for instance, might easily be doubled. Instead of assisting organisation of the tea interests, the Government does nothing at all, while provincial governments are permitted to strangle the trade by arbitrary taxation. China, too, is the biggest producer of silk in the world, and her better qualities are unsurpassed. But owing to inferior and unscientific methods very little of the better qualities of silk is produced. All that the Government appears to do to encourage the industry is to contribute £1,000 a year to an international committee for the improvement of sericulture, although the trade is one that might be indefinitely expanded by the introduction of scientific methods.

Cotton is another Chinese industry that has grown astonishingly during the past few years. The Japanese import enormous quantities of yarn from India because the Chinese production is only the merest trifle of what it might be. The Government actually taxes raw cotton so that the Chinese mills have to pay more for it than their Japanese competitors. Nothing whatever is done officially to promote scientific growth, and it is left to foreigners to try to demonstrate in a small way to Chinese growers what results can be obtained from the use of the right seed, proper care of plants, and correct methods of pruning. There are already 13,000,000 spindles at work in China, a substantial proportion of which are Chinese owned. Here is another trade the potentialities of which are unlimited. The sudden rise of the soya bean produced in Manchuria is one of the commercial wonders of the world, yet the Chinese Government has done nothing to promote its production or sought to introduce it elsewhere. Egg production is another industry with room for great expansion, but utterly neglected except by foreigners who are promoting the trade. Animal husbandry offers infinite scope, the world demands great quantities of vegetable oils, whose originals, the peanut, rapeseed, sesamum, and others, might be cultivated in China in immense quantity at great profit.

There is enough coal in China to run the power-plants of the world far into the millennium, and it is practically untouched but for foreign enterprise. Of iron there are huge deposits known, but the only serious attempt to develop them was so stupidly conducted that the enterprise had to be mortgaged, and Japan now has control of it. There are endless other sources of wealth in China, but in regard to none has the Government ever done anything to promote development. On the contrary, official corruption, jealousy of foreigners, superstition, and, above all, repressive taxation, have operated to strangle enterprise and to retard development.

WAR MACARONI AS MADE IN NAPLES DISTRICT.

Macaroni, which, prior to the war, was one of the chief articles of export from the Naples consular district to the United States, was, on the entry of Italy into the war, placed on the list of prohibited exports, and shortly thereafter its manufacture was put under Government control. The Government supplies the wheat, fixes the "calmiere" or price limit for sales (wholesale and retail), and supervises the distribution.

One of the largest manufacturers of macaroni in the district, writes the United States Consul at Naples, has wholesale offices in Naples and factories at Foggia and Castellamare di Stabia. The plant at Castellamare covers a surface area of 10,000 metres, of which 5,000 metres are occupied by two large four-story brick buildings, connected at the rear by a covered drying shed. The plant cost to build about 2,000,000 lire. The company had just had installed new, expensive oil-burning power machinery when the war broke out. The building nearest the bay is devoted to the milling of flour for the making of macaroni, and contains also modern drying rooms for curing the macaroni in wet weather, while the second building is devoted to the making of macaroni paste and the cutting of it into the many forms and patterns in which it is marketed. This plant is said to be among the most modern and best equipped in Italy.

Macaroni is composed of ground wheat and water and nothing else. In the plant at Castellamare the entire process of manufacturing the ground wheat is done automatically. The term "ground wheat" and not "flour" is used, because in normal times macaroni was not made of soft or rolled flour, but of wheat cut very fine by rollers, so as to resemble a very high quality of corn meal or grits. This is called "semolina."

Wheat arrives at the plant in jute sacks, containing 100 kilos (220·46 lb.) each. It is emptied into hoppers, from which it is conveyed by suction into winnowing bins, where all dust, chaff, and light-weight grain are sifted out. The light-weight grain becomes the first by-product. It is known as "scarto di grano," and is sold for chicken feed at 0·50 lira per kilo (kilo = 2·2046 lb.). The quantity of scarto di grano varies with the quality of the wheat furnished. The best California hard wheat, used before the war, was free from scarto. From the winnowing bins the fat, heavy grains are carried into cylinders, where they are thoroughly washed by a churning process, and pass into other cylinders, where they are dried by air currents slightly heated, and, still by suction, begin to make their passage of the grinding rollers.

There are seven of the grinding mills through which the grain passes. The first breaks it; with the second the coarser glazed envelope of the grain, known as bran, commences to be separated. This bran becomes whiter and finer with each milling process, and the grain is cut finer and more regularly each time, until the perfect semolina is produced. At the same time there is a fine, light, powdery, non-nutritious flour dust that is fanned away, which is afterwards collected and sold added to the bran and used as food for animals. This powdery flour may be said to be the second by-product and the bran the third and last, if they are considered separately.

A quintal (100 kilos, or 220·46 lb.) of washed milling wheat will yield 55 kilos of semolina or cut wheat, 20 kilos of flour or pulverised wheat, and 23 kilos of "crusca" or bran and non-nutritious flour, and 2 kilos will have disappeared or been fanned away in the milling process.

Prior to the war only the true semolina was used for making macaroni, and the 20 kilos of good flour per quintal was a by-product sold for bread-making. The difference in the quality of war macaroni is that this 20 kilos of flour which has been separated from the semolina by milling is by Government order again mixed with the semolina to constitute the raw material for the "tipo Unico" or fixed standard of macaroni paste. This addition of a flour which would be excellent for bread tends to make an inferior grade of macaroni. The macaroni so made dissolves more readily in cooking, but the addition gives about one-third more available macaroni as a food supply, though it correspondingly diminishes the material available for bread. However, macaroni can be sold at a lower price than bread, and in Southern Italy macaroni, and not bread, is the staff of life.

Before the war the semolina was shipped in 100 kilo sacks for the wholesale trade, and now the war mixture semolina is so shipped.

Macaroni paste is made by adding, in a large mortar or mixer, about 25 kilos of water for every 100 kilos of semolina (or war semolina). This is mixed into a stiff paste of the consistency of putty. It will not stick to the fingers. It is then taken to a kneading machine, where fluted rollers work it thoroughly. The paste is then loaded into a cylinder, at the base of which is a perforated metal plate about two inches thick.

This plate is the form or die which determines the shape of the macaroni. The plant at Castellamare has more than 200 different dies or forms for shaping the paste. Some of the forms have names according to their shape, and some have names more or less fantastic.

The plates or dies are interchangeable. The cylinder, which is of steel, is like a huge churn in which the dasher presses the paste against the bottom, whence the paste issues in a form corresponding to the orifices in the plate. The cylinders are in pairs revolving around a central steel shaft, so that while the great dasher is pressing the paste out of one cylinder the other is being charged. About 120 kilos of paste are taken into each cylinder at a time.

Some of the cylinders are placed horizontally instead of vertically, and revolving knife blades

clip the tubes of soft paste as they issue from the plate. The macaroni most in use now is a simple tube about one-fourth inch in diameter cut in this way. These pieces are known as "ditali," or fingers.

The simple vermicelli form, which is a string and not a tube, is also in much favour. This and the ordinary long macaroni tube forms are prepared in the same way. The paste is pressed out through the orifices and allowed to dangle beneath the cylinder until it looks like a fringe one or two yards in length. A boy then takes these paste strings by the armful and throws them over a bamboo pole held up between two supports, and rapidly, by touch, sorts them out until they are spread in a single layer on the pole.

The bamboo poles are placed close together, and the paste is dried in good weather in the open air and in bad weather in a drying room. In the artificial drying room, air, slightly heated, is kept in swift circulation by revolving fans. The short-length macaronis are placed in trays with woven wire bottoms. At some stages the short pieces are spread out like drying seed on tarpaulins in covered rooms. In good weather all macaroni is dried in the open air, the air-cured macaroni being superior in quality to that cured in drying rooms.

The shorter lengths and standard shapes are sold in bulk, packed in 100-kilo jute sacks. Among the patented machinery is a machine for quickly cleaning sacks by a system of beating and suction operating simultaneously. The finer qualities and unusual shapes of paste are packed in coloured cartons or boxes in normal times

At Bologna there are certain variations of the paste itself made which are seldom exported, as they do not keep well. There macaroni is also found in colours of yellow, green, and red. The yellow is made by the addition of eggs for flat cut pastes known as "Bologna tagliatelli." An admixture of spinach gives the green paste, and the blood of the beet furnishes the red colour.

Wheat for macaroni making is of a special quality of hard grain, rich in gluten. Most of it is imported into Italy in normal times, largely from Rumania, although North America furnishes a considerable part.

JAPANESE ENTERPRISE IN THE STRAITS SETTLEMENTS.

The Nan-Yo Kyokai, or Japanese Commercial Museum, in Singapore, the capital of the Straits Settlements, has been open to the public since November 23rd, 1918. Its avowed object is the exhibition of samples and specimens of goods, and the promotion of the commercial development of Japan in what are termed the South Sea districts, viz. the Philippines, the British East Indies, the Dutch East Indies, Indo-China, etc. It is supported by the South Sea Association of Tokio and the Japanese Government, jointly, while the expenses of the students' department are paid by the Association alone. The Museum occupies an entire two-story building of imposing appearance and large dimensions in the central or business portion of the city.

A recent report by the United States Consul-General at Singapore gives the following description of the Museum:—

In the main portion of the ground floor there is a tasteful classified arrangement of all sorts of Japanese manufactures, ranging from machinery of heavy types down to the daintiest articles of handiwork peculiar to the land of Nippon. The articles displayed embrace practically every kind of goods made in Japan for the export trade, including tools, paints, varnishes and chemicals, textiles, photographic and printing materials, rubber manufactures, brass goods, wooden wares, art goods of many varieties, wearing apparel, etc., all skilfully arranged under the direction of a special expert from Japan. The ground floor also accommodates a spacious library and reading-room, well supplied with trade and other literature for the information and convenience of visitors; a large, admirably-arranged office space for the working staff, and a refreshment buffet.

Another feature of the institution, quite apart from the commercial museum, is the students' hall, which occupies the upper story of the building, where residential and class rooms are provided for Japanese students who are here being specially trained for the work of promoting Japanese trade and commerce in this and other parts of the East Indies. These students are given special instruction in the English, Dutch, Malayan, and other languages, as well as in economics, etc. Instruction is free, but all other expenses must be met by the students themselves.

Each graduate of the school must establish himself with some commercial, agricultural, or industrial firm in the East Indies, or a firm in Japan that has relations with the East Indies. The students are expected to remain at the school for a period of about one year, when they will go on to India or elsewhere to pursue other studies in line with their chosen vocation, their places being taken by other recruits from Japan. Facilities are offered for indulging in healthy outdoor sports, such as tennis, football, baseball, swimming, etc., and in all other respects the students have the benefit of regular college life.

In addition to the course marked out for the regular or official students sent out from Japan, optional evening classes, in charge of local teachers, are open to Japanese residents in Singapore.

In order to accomplish the aims for which the Museum was established, its activities are officially stated to be directed as follows:—

1. To exhibit samples of the manufactures of Japan, and explain them, in order to introduce them to foreigners.

2. To exhibit reference patterns of goods made in foreign countries for purposes of comparison and study.

3. To try to improve and develop the quality or design of goods made in Japan.

4. To give an opinion about commodities, if it be desired by applicants.

5. To exhibit samples of goods much in demand in the South Sea districts in the Museum, and to send similar samples to other like institutions in Japan for Japanese manufacturers to see.

6. To send on request samples of industrial materials which are produced in the South Sea districts.

7. To comply with requests regarding the introduction of commercial transactions.

8. To open up communication, exchange printed matter, or lend, borrow, or assign samples of commodities with domestic or foreign commercial and industrial bodies.

9. To comply with requests concerning various investigations and reports of enterprises, trade, or other affairs, and from time to time publish those investigations and reports, and the periodical reports of the Museum in which the above-mentioned matters will appear.

10. To furnish reports, statistics, and books about enterprise, trade and other economic matters, and newspapers, magazines and reference books for public perusal.

A catalogue of the exhibits will be published by the Museum from time to time for distribution to persons interested.

CATTLE-RAISING IN BRAZIL.

All the States of Brazil, on account of their vast size, possess large areas of pasturage, and certain of these are to a great extent entirely devoted to stock-raising. In the interior of the country, the Caracú, Franqueira, Curraleiro, Mocho, and Pantaneiro, native types of cattle, have been known for many years. In addition the following foreign breeds have been imported and successfully raised—Holland, Flemish, Swiss, Guernsey, Limousine, Hereford and Zebú.

The Swiss, Holland and Guernsey breeds show the greatest resistance to climatic conditions. The Swiss type has done most to regenerate native breeds, and reaches the highest degree of development in weight, production of milk, and adaptation to environment in Brazil. Despite its easy adaptation, special care must be taken in breeding the Holland cattle, good pasturage, humidity, and low altitude being essentials. The Guernsey, although quickly adapted to new environment, loses in part the properties of fat contained in its milk, and its production is diminished.

The coefficient of mortality of the Flemish type is about 33 per cent. during acclimatisation, and though this type becomes perfectly adapted, it is inadvisable to introduce it into regions of high altitude or scanty pasturage. Limousine cattle become thoroughly adapted to the climate of the country under all conditions of temperature and pasturage.

The climatic zones of Brazil include the tropical, sub-tropical, and temperate zones. The tropical zone covers that district where the temperature rises above 25° C. (77° F.), *i.e.* the States of Parahyba, Rio Grande do Norte, Ceará, Piauhy, Maranhão, Pará, and Amazonas, a part of Goyaz and Matto Grosso, as far south as the city of Cuyabá. According to conditions of rainfall, the tropical zone may be sub-divided into three parts: the Upper Amazonas, adapted to the breeding of cattle for slaughter, particularly the Hereford, which may be crossed with native animals of the region; the second section, namely, the interior of Maranhão, Pará, Matto Grosso, and Piauhy, suited to beef cattle such as Hereford and Limousine types; the third region, including the hot and humid coastal territory in Pará, Maranhão, Piauhy, Ceará, Rio Grande do Norte, and Parahyba, adapted to the raising of milk cattle and mixed types, the Holland serving better for the former purpose, the Limousine for the latter.

The sub-tropical zone has three regions. The first, covering Pernambuco, Alagoas, Sergipe, and the coast of Bahia, is suited to the Swiss, Limousine and Holland types; the second, including Espirito Santo, Rio do Janeiro, the southern part of Bahia, and part of the coast of São Paulo, is adapted to raising Hereford, Limousine, Swiss, Holland, and Flemish breeds. The third division, characterised by irregularity of season, comprises the interior of Minas Geraes, and the eastern and southern parts of São Paulo, and is suited to the introduction of Swiss, Holland, Limousine and mixed breeds.

In the temperate zone, *i.e.* Parana, Santa Catherina, Rio Grande do Sol, part of São Paulo and Minas Geraes, the Hereford and Limousine cattle are suitable for breeding, and the Flemish and Holland as milk races. The Swiss is admirably adapted to this region, both as a beef animal and a milk producer.

According to a report by the United States Vice-Consul at Rio de Janeiro, cattle-raising in Brazil has been greatly improved and extended within the last few years by the importation of the best type of breeders for reproductive purposes. The industry has undergone a rapid development recently, the world shortage of meat products during the war having emphasised the possibilities of Brazil as a meat-producing country. One of the most active agencies toward the betterment of the Brazilian herd has been the Sociedade Nacional de Agricultura (National Society of Agriculture), which in 1917 inaugurated the first annual cattle show in Brazil. The show was attended with great success in 1918. The Society hopes, through cattle shows and other means, to accomplish results along the lines of similar organisations in other countries. The Federal and State Governments have likewise taken a great interest in the cattle industry, assisting breeders and importers in many ways.

With the establishment of three large American packing houses in Southern Brazil, cattle-raising seems bound to assume international importance. The demand of the concerns mentioned for a

regular supply of cattle for slaughtering purposes will tend to interest ranchmen, and with the extension of existing and construction of new railways it is expected that the industry, conducted on a large scale, will make for a new source of national prosperity and be the means of opening up hitherto undeveloped sections of the country.

CORRESPONDENCE.

THE SIX-HOUR DAY.

In the *Journal* of September 26th I notice, in the abstract from Dr. H. M. Vernon's paper before the Physiological Section of the British Association, Lord Leverhulme's suggestion for two six-hour shifts was taken up. In the third paragraph it is stated that the workers suffer from monotony and boredom. This is exceedingly true under modern specialised methods. The solution, however, is not to work them shorter hours, but to work just as long hours and vary the work during these hours. If it were possible under Lord Leverhulme's scheme to do six hours' factory labour and two or four hours agricultural labour, or some other labour of a productive nature, the world's shortage in production would be readily met, with benefit to the worker.

The problem facing the worker just now is not the problem of shorter hours, but the problem of what he is to do with longer leisure. At the Ford plant in Detroit, where a strict eight-hour day is worked, it has been found that men actually work two eight-hour shifts during the twenty-four. The problem of the leisure period should be studied simultaneously with the problem of shorter hours.

JOHN YOUNGER.

Standard Steel Car Company,
Pittsburgh, Pa.,
October 28th, 1919.

NOTES ON BOOKS.

THE STROWGER AUTOMATIC TELEPHONE EXCHANGE. By R. Mordin. London: E. & F. Spon, Ltd.; New York: Spon & Chamberlain. 21*s*. net.

At a time when the complaints about our telephone service are more numerous and forcible than ever, a special interest attaches to this volume. The Strowger system originated in the United States, where automatic telephony plays a much larger and more important part in business and in social life than it can yet claim to do in this country. Beginnings have, however, been made here, and equipments on the Strowger system have been installed at Accrington, Paisley, Portsmouth, Newport, Blackburn, Leeds, Rosyth, and Chepstow, as well as at Epsom and the official switch at the General Post Office, London.

The object of the automatic telephone is to enable subscribers to obtain interconnection without the intervention of an operator. The advantages claimed for the Strowger system are forcibly summed up by Mr. Mordin as follows: *For the user:* (1) Elimination of all trouble due to faulty operating; (2) absolute privacy; (3) completion of connection in not more than six seconds; (4) automatic, and therefore immediate, advice if the called subscriber is engaged; (5) instantaneous clearing; (6) constant and uniform service day and night. *For the operating authority:* (1) saving of operators' wages, training expenses, and accommodation; (2) economy of space; (3) economy of line construction; (4) no limit to size of exchange; (5) very low maintenance charge, long life, and comparative immunity from faults.

The Strowger system is described very clearly and fully by Mr. Mordin, with the aid of a large number of illustrations in the text and plates. As the system has been well tested in America for some time, it is long past the experimental stage, and one can only hope that the day is not far distant when it will be the rule rather than the exception to find it installed here.

THE NEW BRAZIL: its Resources and Attractions, Historical, Descriptive, and Industrial. Second Edition. By Marie Robinson Wright. Philadelphia: George Barrie & Sons; London: C. D. Cazenove & Son.

Miss Marie Robinson Wright is well known as the author of some admirable popular books on Mexico, Chile, Bolivia, and Peru. She has now turned her attention to Brazil, and in the very handsome volume before us she gives an excellent account of the country which she believes to be on the edge of a great development, such as took place in the United States during the nineteenth century.

The first five chapters are devoted to the history of Brazil, from the time of its discovery by Pedro Alvares Cabral in 1500 to the present day. These are followed by an account of the President's Cabinet, and then come a series of chapters describing the new federal capital, the suburbs of Rio, and its music, art, and literature. After these the various provinces of Brazil, with their industries, are dealt with; and from this it will be seen that the five hundred pages of which the volume consists are not too much for so extensive a subject.

Where all is excellent it is not easy to select any points for particular discussion. Perhaps the chapters most likely to interest readers of the *Journal* are those which deal with the industries of Brazil, especially rubber and coffee. Of the prospects of the Amazon country the author writes with great optimism. The amount of rubber exported by the State of Amazonas in 1906 was 19,000 tons—about one-third of the world's total supply; while the entire exports from the Amazon countries for that year amounted to 43,000 tons. A good account is given of the methods of tapping, preparing and classifying rubber.

The export of coffee from Brazil started in 1817, when some 60,000 bags were shipped. In 1906 the

country produced 13,125,000 bags, or more than three-quarters of the total production of the world. The centre of this great coffee-growing region is São Paulo, in which there are some 700,000,000 coffee trees. The author gives a good description of the plantations, and of the harvest, the drying of the beans, and their shipment to all parts of the world.

The book is abundantly illustrated with portraits, views of towns, and landscapes. Some of the last are very striking, especially a double-page picture of Rio de Janeiro. The entrance to this magnificent harbour is as fair a picture as is to be found on the earth. It is dotted with beautiful islands bathed in a tropical sea, in which the big liners ply, while the town nestles among romantic hills and fascinating ravines. It is easy to understand the enthusiasm with which the author writes of her subject, and to sympathise with the poet who sang—

"I'd love to roll to Rio
Some day before I'm old."

REINFORCED CONCRETE CONSTRUCTION. By M. T. Cautell. Second Edition. London: E. & F. N. Spon, Ltd.; New York: Spon & Chamberlain. 7*s.* 6*d.* net.

Reinforced concrete possesses many obvious advantages, the chief of which are rigidity; lightness combined with strength; durability and resistance when exposed to the action of fire, water, or acid-laden atmosphere; adaptability to all forms of architectural and structural work; saving of space; economy of cost; rapidity of erection; and no depreciation, but rather an increase of strength with age. With all this in its favour there is little wonder that its use is rapidly increasing. It is employed in the construction of residences, from workmen's cottages to millionaires' mansions, for business premises of all sizes, for hotels, churches, theatres, hydro-electric power stations, gas-works, factory chimneys, reservoirs —in fact, there is hardly a constructional purpose for which it is not suitable. It is far superior to brick, wood, or stone in resisting water, fire, or earthquake; the author mentions that the city of Messina has been entirely rebuilt in reinforced concrete.

In view of the many uses to which it is already put, and of its almost boundless possibilities in the future, there is a great need for a simple, sound, and workmanlike text-book for students. Mr. Cautell's volume meets this need. It is divided into two parts, the first dealing with principles, general information, and examples of designing, while the second contains more advanced examples and illustrations of all types of structure.

GENERAL NOTES.

JAPAN AND INDIA.—An article in the *Board of Trade Journal* of November 6th calls attention to the fact that Japan's trade with India exceeds that of all other countries except the United Kingdom. The Japanese exports during the official year 1918-19 amounted to £22,333,333, practically a fifth of the whole of India's imports. The census of 1911 showed that there were then only thirty-two male Japanese in India, excluding Burma; there are now large Japanese colonies in Bombay and Calcutta, and they seem to be steadily growing in numbers and importance. Three years ago there was only one Japanese exchange bank; at present there are three such banks. Ten years ago the greater part of the Japanese consignments to India were carried by British ships, financed by British banks, and distributed by British or Indian traders. Now, however, 90 per cent. of these goods go in Japanese steamers; are, to a large extent, consigned to Japanese firms, and distributed by Japanese nationals. In the export trade similar conditions obtain. "The Japanese Cotton Spinners' Association practically dominates the market for raw cotton, and Japanese buyers are found in the cotton markets in the rural areas. In many cases they gin and bale their own purchases." With regard to the exports, there are strong probabilities that the figures for next year will show a substantial decline. "From many quarters come reports of a growing dissatisfaction with Japanese goods on the part of the Indian consumer." In this connection it may not be inappropriate to mention that among the passengers who sailed on November 1st from Tilbury for Bombay, in the steamship "Loyalty," are 170 British business men, for whom accommodation had been arranged by the Department of Overseas Trade.

WATER-POWER RESOURCES IN INDIA.—By order of the Government of India a systematic investigation of the water-power resources of that country was made last winter. In a preliminary report it is stated that a round estimate of 1,774,000 electrical horse-power in sight is vastly below the actual power which the final results of the survey will show. The following figures of known and probable sites where there is a reasonable prospect of obtaining power are given:—

Name of Province.	Continuous electrical horse-power.
Assam	51,200
Bengal	203,600
Bihar and Orissa	12,800
Bombay	258,300
Burma	439,000
Central Provinces	153,000
Cochin	25,000
Kashmir	30,000
Madras	106,000
North-West Frontier Province	20,000
Punjab	260,900
United Provinces and Benares	32,200
Total	1,592,000

MEETINGS FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 17...Swiney Lectures, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Dr. J. D. Falconer, "The Geology and Mineral Resources of the British Possessions in Africa." (Lecture IV.)

East India Association, 7, Tothill-street, Westminster, S.W., 3.45 p.m. Mr. S. P. Price, "A German on India."

Geographical Society, 135, New Bond-street, W., 8.30 p.m. Sir A. Sharpe, "A Recent Journey in Liberia."

University of London, University College, Gower-street, W.C., 5.30 p.m. Mr. R. A. Rye, "The Oldest Book in the World and its Story."

TUESDAY, NOVEMBER 18...Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Rear-Admiral P. Dumas, "The Conservation of Oil."

Industrial League, Council Chamber, Guildhall, E.C., 4.30 p.m. Sir Auckland Geddes, "Industrial Outlook."

University of London, University College, Gower-street, W.C., 5.30 p.m. Mr. J. H. Helweg, "Holberg and Ewald." (Lecture III.)

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Mr. E. H. Godfrey, "Fifty Years of Canadian Progress, 1867-1917."

Electrical Engineers, Institution of (North-Western Centre), 17, Albert-square, Manchester, 7 p.m. Address by Chairman, Mr. J. A. Robertson.

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Mr. M. F. Wilson, "Admiralty Harbour, Dover."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 7.30 p.m. Mr. H. K. Prossor, "Discord and Harmony of Colour in Decoration."

Photographic Society, 35, Russell-square, W.C., 7 p.m. Dr. G. H. Rodman, "The Story of the Cuckoo Spit."

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. Sir E. G. Loder, "Exhibition of the skull of a Beaver." 2. Major J. S. Hamilton, "Field-Notes on some Mammals in the Bahr el Gebel, Southern Sudan." 3. Dr. J. F. Gemmill, (*a*) "The Development of the Mesenteries in *Urticina crassicornis* (Actinozoa)"; (*b*) "The Leptomedusan *Melicertidium octocostatum*." 4. Mr. M. Turner, "On the Nematode Parasites of a Chapman's Zebra" 5. Rev. A. H. Cooke, "The Radula of the Mitridæ." 6 Lieut.-Colonel S. M. Copeman, "Experiments on Sex Determination." 7. Dr. C. F. Sonntag, "The Variations in the Digastric Muscle of the Rhesus Macaque and the Common Macaque." 8. Mr. E. S. Russell, "Note on the Righting Reaction in *Asterina gibbosa* Penn."

WEDNESDAY, NOVEMBER 19...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Opening Meeting of the 166th Session. Address by Sir Henry Trueman Wood (Chairman of Council), "Science and Industry."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Professor O. L. Fortescue, "The design of Multiple Stage Amplifiers using Three Electrode Thermionic Valves."
(South Midland Centre.) The University, Edmund-street, Birmingham, 7 p.m. Address by Chairman, Dr. C. C. Garrard.

University of London, University College, Gower-street, W.C., 3 p.m. Dr. E. G. Gardner, "History and Drama in the Divina Commedia." (Lecture V.) 5.30 p.m. Mr. H. E. Palmer, "Methods of Learning Foreign Languages." (Lecture III.) Mr. I. C. Gróndahl, "Holberg and Wessel." (Lecture III.) 6.15 p.m. Dr. J. C. Stamp, "Fundamental Principles of Taxation in the Light of Modern Developments." (Lecture III.)

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Lieutenant C. W. B. Normand, "The Effect of High Temperature, Humidity and Wind on the Human Body." 2. Captain A. J. Bamford, "Some Observations of the Upper Air over Palestine." 3. Mr. E. G. Bilham, "Barometric Pressure and Underground Water Level."

Geological Society, Burlington House, W., 8 p.m.

Microscopical Society, 20, Hanover-square, W., 8 p.m. 1. Mr. H. M. Carleton, "Note on Cajal's Formalin-silver Impregnation Method for the Golgi Apparatus." 2. Mr. F. I. G. Rawlins, "Report on the Collection of Metallurgical Specimens recently presented to the Society by Sir R. Hadfield, Bart., F.R.S."

United Service Institution, Whitehall, S.W., 3 p.m. Mr. D. Ogg, "German Naval Propaganda."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5 p.m. Lord Charnwood, "Wordsworth and his Life's Work."

Oriental Studies, School of, Finsbury-circus, E.C., 5 p. Mr. L. Binyon, "The Art of Asia." (Lecture I.)

Swiney Lectures, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Dr. J. D. Falconer, "The Geology and Mineral Resources of the British Possessions in Africa." (Lecture V.)

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Mrs. S. A. Barnett, "Public and Individual Housing Ideals."

THURSDAY, NOVEMBER 20... Gas Engineers and Managers (Southern District Association), at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m.

Ophthalmic Opticians, Institute of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 6 p.m. Dr. D. Forsyth, "The Pre-School Girl."

Chemical Society, Burlington House, W., 8 p.m.

University of London, University College, Gower-street, W.C., 5.30 p.m. Professor A. Cippico, "La Poesia di Giovanni-Pascoli." (Lecture II., in Italian.) Mr. I. Bjorkhagen, "Selma Lagerlof." (Lecture III.)

Electrical Engineers, Institution of (Irish Centre), Royal College of Science, Upper Merrion-street, Dublin, 7 p.m. Discussion on Mr. C. H. Wordingham's address.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

FRIDAY, NOVEMBER 21...Engineers, Junior Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7 p.m.

Swiney Lectures, Imperial College of Science, South Kensington, S.W., 5.30 p.m. Dr. J. D. Falconer, "The Geology and Mineral Resources of the British Possessions in Africa." (Lecture VI.)

Mechanical Engineers, Institution of, Storey's-gate, Westminster, S.W., 6 p.m. Mr. C. G. Conradi, "The Present Position of Mechanical Road Traction."

CONTRIBUTIONS TO THE READING-ROOM.

The Council have to acknowledge, with thanks to the Proprietors, the receipt of the following Transactions of Societies and other Periodicals.

TRANSACTIONS, ETC.

Aëronautical Society, Journal.
African Society, Journal.
American Academy of Arts and Sciences, Proceedings.
American Chemical Society, Journal.
American Institute of Architects, Journal.
American Institute of Electrical Engineers, Transactions.
American Institute of Mining Engineers, Transactions.
American Leather Chemists' Association, Journal.
American Philosophical Society, Proceedings and Transactions.
American Society of Civil Engineers, Transactions.
American Society of Mechanical Engineers, Journal.
Amsterdam, Koloniaal Instituut, Bulletin.
Architectural Association, Journal.
Auctioneers' and Estate Agents' Institute, Record.
Australasian Association for the Advancement of Science, Report.
Australian Official Journal of Patents.
Bagnères-de-Bigorre, Société Ramond, Bulletin.
Bath and West of England Society, Journal.
Bombay, Royal Asiatic Society, Journal.
British Association for the Advancement of Science, Report.
British Dental Association, Journal.
British Fire Prevention Committee, Publications.
Brussels, Société Belge d'Études Coloniales, Bulletin.
Canada, Royal Society, Proceedings and Transactions.
Central Chamber of Agriculture, Journal.
Chartered Institute of Patent Agents, Transactions.
Chemical Society, Journal.
Chicago, Field Museum of Natural History, Publications.
Chicago, Western Society of Engineers, Journal.
Cleveland Institution of Engineers, Proceedings.
Cold Storage and Ice Association, Proceedings.
Commonwealth Institute of Science and Industry, Journal.
Concrete Institute, Transactions.
East India Association, Journal.
Engineering Institute of Canada, Journal.
English Language Union, The Future.
Farmers' Club, Journal.
Franklin Institute, Journal.
Geneva, Société des Arts, La Revue Polytechnique.
Geological Society, Quarterly Journal.
Geologists' Association, Proceedings.
Glasgow, Royal Philosophical Society, Proceedings.
Imperial Arts League, Journal.
Imperial Department of Agriculture for the West Indies, Publications.
Imperial Institute, Bulletin.
India, Geological Survey, Memoirs and Palæontologia Indica.
Indian Meteorological Department, Monthly Weather Review.
Institute of Bankers, Journal.
Institute of Brewing, Journal.
Institute of British Carriage Manufacturers, Journal.
Institute of Chemistry, Proceedings.
Institute of Metals, Journal.
Institute of Sanitary Engineers, Journal.
Institution of Automobile Engineers, Proceedings.
Institution of Civil Engineers, Minutes of Proceedings.
Institution of Civil Engineers of Ireland, Transactions.
Institution of Electrical Engineers, Journal.

Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Gas Engineers, Transactions.
Institution of Mechanical Engineers, Journal and Proceedings.
Institution of Mining and Metallurgy, Transactions.
Institution of Municipal and County Engineers, Proceedings.
Institution of Naval Architects, Transactions.
Institution of Petroleum Technologists, Journal.
Iron and Steel Institute, Journal.
Japan Society, Transactions and Proceedings.
Johannesburg, Chemical, Metallurgical and Mining Society, Journal.
Junior Institution of Engineers, Record of Transactions.
Kew Gardens Bulletin.
Kyoto, Imperial University, Memoirs of the College of Science.
Lima, Ministerio de Fomento, Boletin.
Linnean Society, Journal.
Lisbon, Sociedade de Geographia, Boletim.
Liverpool, Engineering Society, Transactions.
———, Literary and Philosophical Society, Proceedings.
Lyons, Société d'Agriculture, Sciences et Industrie, Annales.
Manchester Literary and Philosophical Society, Memoirs and Proceedings.
———, Municipal School of Technology, Journal.
——— Steam Users' Association, Reports.
——— Textile Institute, Journal.
Michigan Academy of Science, Reports.
Milan, Associazione Elettrotecnica Italiana, Atti.
———, Collegio degli Ingegneri ed Architetti, Atti.
National Indian Association, "The Indian Magazine and Review."
National Physical Laboratory, Collected Researches.
New South Wales, Royal Society, Journal and Proceedings.
New York Academy of Sciences, Annals and Memoirs.
North-East Coast Institution of Engineers and Shipbuilders, Transactions.
Norwich, Operative Brewers' Guild, Journal.
Nova Scotian Institute of Science, Transactions.
Paris, Bureau Veritas, Bulletin Technique.
——, Comité International des Poids et Mesures, Procès Verbaux.
——, Conservatoire National des Arts et Métiers, Annales.
——, Société d'Encouragement pour l'Industrie Nationale, Bulletin.
——, Société de Géographie Commerciale, Bulletin.
——, Société des Ingénieurs Civils, Mémoires.
——, Société Internationale des Electriciens, Bulletin.
——, Société Nationale d'Acclimatation de France, Bulletin.
Patent Office, Illustrated Official Journal.
Pennsylvania (Western), Engineers' Society of, Proceedings.
Philadelphia, Academy of Natural Sciences, Proceedings.
Philadelphia, Engineers' Club, Journal.
Physical Society, Proceedings.
Quekett Microscopical Club, Journal.
Royal Agricultural Society, Journal.
Royal Asiatic Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Canadian Institute, Transactions.
Royal Cornwall Polytechnic Society, Annual Report.
Royal Dublin Society, Proceedings and Transactions.
Royal Horticultural Society, Journal.
Royal Institute of British Architects, Journal.
Royal Institution of Great Britain, Proceedings.
Royal Irish Academy, Transactions and Proceedings.
Royal Meteorological Society, Quarterly Journal and Record.
Royal National Life Boat Institution, "The Life-Boat" and Annual Report.
Royal Sanitary Institute, Journal.
Royal Scottish Society of Arts, Transactions.
Royal Society, Philosophical Transactions and Proceedings.
Royal Society of Edinburgh, Transactions and Proceedings.
Royal Statistical Society, Journal.
Royal United Service Institution, Journal.
St. Louis Engineers' Club, Journal.
Smithsonian Institution, Report and Publications.
Society of Antiquaries, Archæologia and Proceedings.
Society of Architects, Journal.
Society of Biblical Archæology, Proceedings.
Society of Chemical Industry, Journal.
Society of Dyers and Colourists, Journal.
Society of Engineers, Transactions.
South African Association for the Advancement of Science, Report.
South Wales Institute of Engineers, Proceedings.
Tokyo, Imperial University, Journal of the College of Science.
Tramways and Light Railways Association, Journal.
Victoria Institute, Journal of the Transactions.
Washington, National Academy of Sciences, Proceedings.
Wisconsin Academy of Sciences, Transactions.

JOURNALS.

Weekly.

Aeronautics.
Amateur Photographer.
American Machinist.
Architect.
Athenæum.
Auto-Motor Journal.

Board of Trade Journal.
Bradstreet's.
British Journal of Photography.
Builder.
Building News.
Cabinet Maker.
Chemical News.
Chemist and Druggist.
Colliery Guardian.
Contractors' Record.
Economist.
Electrical Review.
Electrician.
Electricity.
Engineer.
Engineering.
Engineering and Industrial Management.
English Mechanic.
Flying.
Gardeners' Chronicle.
Gas Journal.
Greater New York.
Grocer.
Indian Engineering.
Industrial Australian and Mining Standard.
Iron and Coal Trades Review.
Journal of Agricultural Research (Washington).
Lancet.
Leather.
London County Council Gazette.
London Teacher.
Machinery.
Machinery Market.
Mechanical World.
Medical Press and Circular.
Model Engineer and Electrician.
Motor Traction.
Musical Standard.
Nature.
Near East.
Page's Weekly.
Pharmaceutical Journal.
Pitman's Journal.
Practical Engineer.
Produce Markets' Review.
Public Opinion.
Pulp and Paper Magazine of Canada.
Railway News.
Sanitary Record.
Saturday Review.
Scientific American.
Shipping World.
Spectator.
Textile Mercury.
Work.

Fortnightly.

Agricultural News (Barbados).
Dyer and Calico Printer.
Finance Chronicle.
Jeweller and Metalworker.
Junior Mechanics and Electricity.
Madrid Cientifico.
Perak Government Gazette.
Revue du Travail.
Revue Générale des Sciences.
Technical Review.
West India Committee Circular.

Monthly.

Acetylene Lighting and Welding Journal.
American Photography.
Analyst.
Arms and Explosives.
Automobile Engineer.
Board of Agriculture Journal.
Bookseller.
Brewers' Journal.
British Esperantist.
British Trade Journal.
Chamber of Commerce Journal.
Chimie & Industrie.
Cold Storage and Ice Trades Review.
Co-partnership.
Cotton (Atlanta).
Decorator.
Engineering Review.
Gas and Oil Power.
Geographical Journal.
Geographical Review (New York).
Giornale del Genio Civile (Rome).
Horological Journal.
Ice and Cold Storage.
Illuminating Engineer.
Imperial Colonist.
International Sugar Journal.
Investor's Monthly Manual.
Journal d'Agriculture Tropicale.
Leather Trades' Review.
Master Builder.
Miller.
Mining Magazine.
Moniteur Scientifique.
Musical Times.
Mysore Economic Journal.
Notes and Queries.
Paper Maker.
Paper Makers' Monthly Journal.
Philosophical Magazine.
Photographic Journal.
Pottery Gazette.
Power User.
Propriété Industrielle (Berne).
Science Abstracts.
Scottish Geographical Magazine.
Secretary.
South African Engineering.
South African Journal of Industries.
Steamship.
Studio.
Symons's Meteorological Magazine.
Textile Manufacturer.
Textile Recorder.
United Empire.
Watchmaker, Jeweller, and Silversmith.
Water and Water Engineering.
Wireless World.

Quarterly.

Agricultural Journal of India.
Colonial Journal.
Edinburgh Review.
Educational Times.
Quarterly Review.
West Indian Bulletin.

NEWSPAPERS.

Canadian Gazette.
Ceylon Observer (Overland Edition).
Englishman (Calcutta).
Home and Colonial Mail.
London and China Telegraph.
London Commercial Record.
Madras Weekly Mail.
Newcastle Weekly Chronicle.
Pioneer Mail (Allahabad).
South Africa.
Times of Ceylon (Weekly Summary).
Times of India (Overland Weekly Edition).

The issue of many of the Publications formerly received by the Society has been interrupted by the War, and their names have been temporarily removed from this list.

INDEX TO VOL. LXVII.

C.

D.

M.

N.

O.

P.

R.

S.

T.

U.

V.

W.